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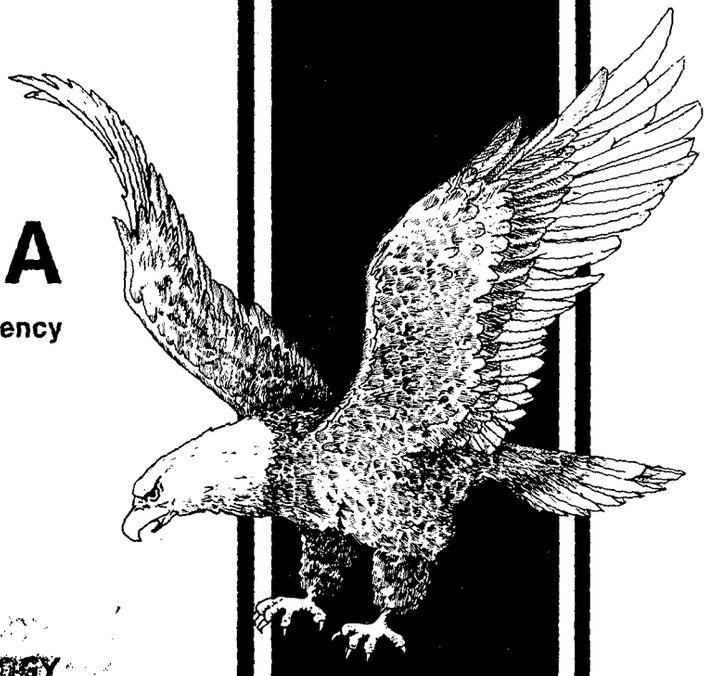
USATHAMA

U.S. Army Toxic and Hazardous Materials Agency



CHARACTERIZATION REPORT FOR U.S. ARMY MATERIALS TECHNOLOGY LABORATORY RESEARCH REACTOR

AUGUST 1990

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FOR
U.S. ARMY MATERIALS TECHNOLOGY LABORATORY
RESEARCH REACTOR

August 1990

Prepared by
EG&G Idaho, Inc.
Idaho National Engineering Laboratory
As Part of Work for Others Project No. 88845

Prepared for the
United States Army Toxic and Hazardous Materials Agency
Base Closure Division
Aberdeen Proving Ground, Maryland 21010
and for the U.S. Department of Energy
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SUMMARY

This report describes the characterization for the decommissioning of the U.S. Army Materials Technology Laboratory (AMTL) Research Reactor, located at Watertown, Massachusetts. The characterization determined the radioactive and chemical contaminants present at the reactor facility to support the efforts to plan the decommissioning of this facility.

The AMTL research reactor was constructed in the late 1950s and 1960. The reactor started operations in June 1960 and continued through June 1970, when the reactor was deactivated. The reactor was used by AMTL as well as other Army arsenals, research centers, and local institutions to conduct various solid-state physics research experiments and programs. Since the reactor deactivation in 1970, the reactor containment facility has been used to house various radiography experiments.

Reactor operations reports for the period June 15, 1960, through March 27, 1970, and the facility safety reports indicate that there was no fuel breached during reactor operations or fuel transfers. The low levels of radioactivity and contamination found in the reactor vessel and on the reactor components during the surveys further substantiate these indications. It is not anticipated that any significant problems relating to the finding of unsuspected contamination will be encountered during the decommissioning of the reactor facility.

Analyses of sediment and soil samples collected around Building 100 and Cistern 242 during March 1990 did not detect any volatile or semivolatile organics, polychlorinated biphenyls/organochlorine pesticides, organophosphorus pesticides/chlorinated herbicides, metals, lead or mercury at levels above Environmental Protection Agency regulatory limits pertaining to the identification and classification of hazardous wastes [as specified in 40 CFR 261, "Identification and Listing of Hazardous Waste," and including the toxicity characteristic revisions effective September 25, 1990 (Federal Register, March 29, 1990)]. Analysis of these samples for alpha and gamma emitters also indicate no findings significantly above background.

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1. INTRODUCTION AND OBJECTIVES

The United States Army Toxic and Hazardous Materials Agency (USATHAMA) requested assistance from the Idaho National Engineering Laboratory (INEL) to perform the planning required to support the decommissioning of the U. S. Army Materials Technology Laboratory (AMTL) Research Reactor, located at Watertown, Massachusetts. The location of the reactor is shown in Figure 1.

The characterization was performed by EG&G Idaho, Inc., to determine the radioactive and chemical contaminants present at the reactor facility. The data included in this report will be used to support the options presented in the Decision Analysis Report, to be published.

This report provides a facility description and history, and radiological characterization and findings for future decommissioning of Building 100, the research reactor containment building; piping in Building 97, which housed the liquid-waste handling system for the reactor; and Cistern 242, which is a retention tank that was used for storage of the liquid waste from the reactor.

The radiological characterization identifies the location and intensity of radiation fields, the principal isotopes, and the areas of contamination in the reactor facility. Potential problems associated with the decommissioning of the facility are also explained in this report.

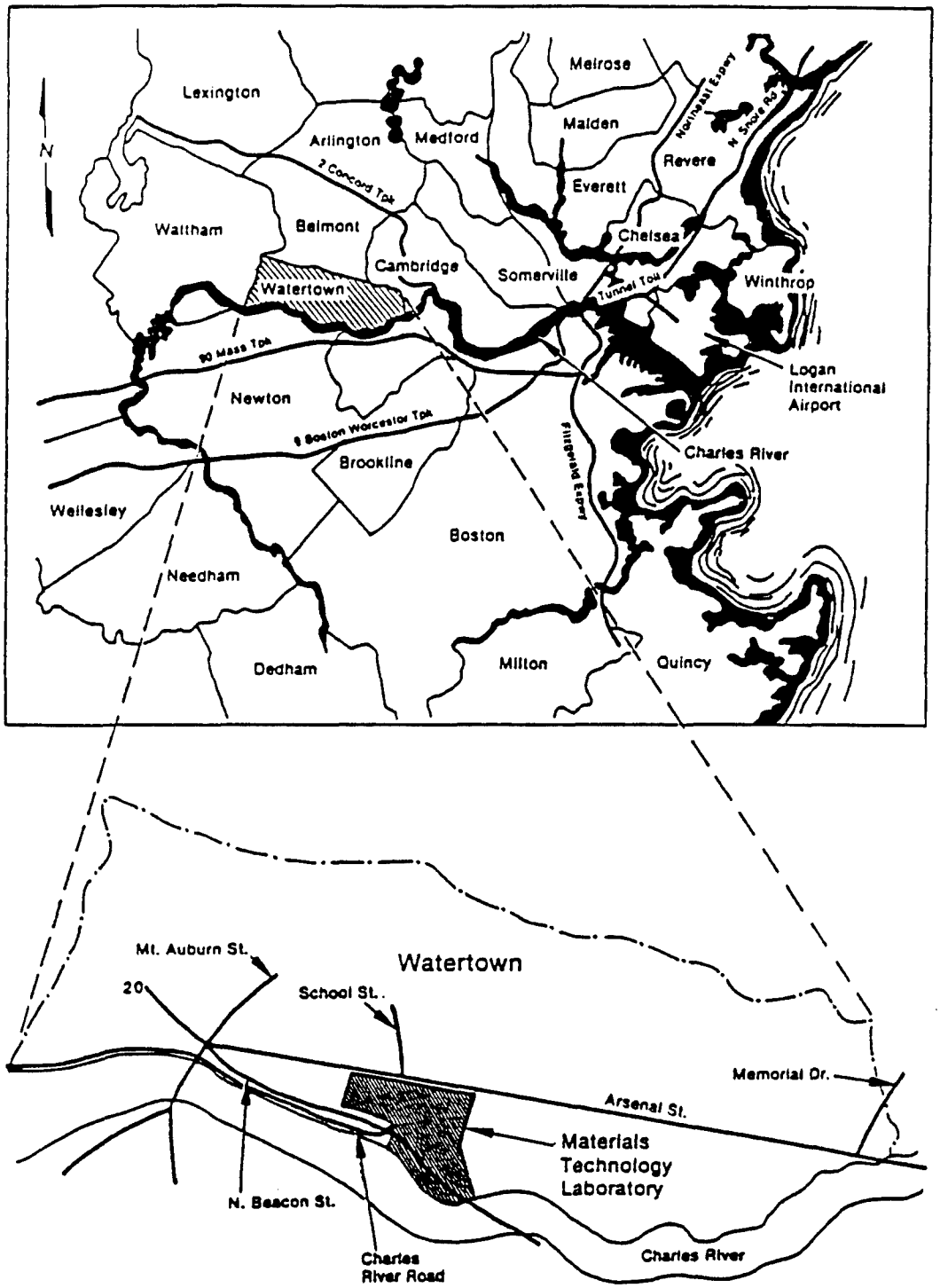


Figure 1. Location of Army Materials Technology Laboratory in Watertown, Massachusetts.

2. HISTORY AND BACKGROUND

2.1 History

The first nuclear research reactor designed to meet the needs of the research programs on materials for the U.S. Army Ordnance Corps was constructed at Watertown, Massachusetts, during the late 1950s and 1960. The reactor was dedicated on May 17, 1960, to the memory of the late Dr. Horace Hardy Lester, who won national recognition as a pioneer in the field of industrial radiography. Figure 2 is a general site map of the AMTL, including Building 100, the AMTL nuclear reactor containment facility.

Initial criticality of the nuclear reactor was achieved on June 15, 1960, at a power level of 1 MW. Post-neutron tests consisting of shim rod calibrations, power calibration, temperature and void coefficients of reactivity measurements, and determinations of the worth of experimental facilities were conducted, culminating on September 16, 1960.[1]

Various solid-state physics research programs and experiments were conducted at the 1 MW power level through June 1966 by the Army Materials and Mechanics Research Center (AMMRC, now AMTL). The reactor was also used extensively by the U.S. Army Picatinny Arsenal for study of explosive-type materials. Other U.S. Army users included the Detroit and Frankford Arsenals and the Natick and Electronics Research and Development Laboratories. Some of the programs conducted by the reactor users included: experiments in the structure of heavy-metal azides, lattice dynamics studies on explosive-type materials and determinations of vibrational spectra of organic secondary explosives, polycrystalline and single-crystal coherent scattering materials and liquids, activation analysis of samples containing trace impurities, and inducing slight radiation effects in materials.[1,2,3,4,5,6]

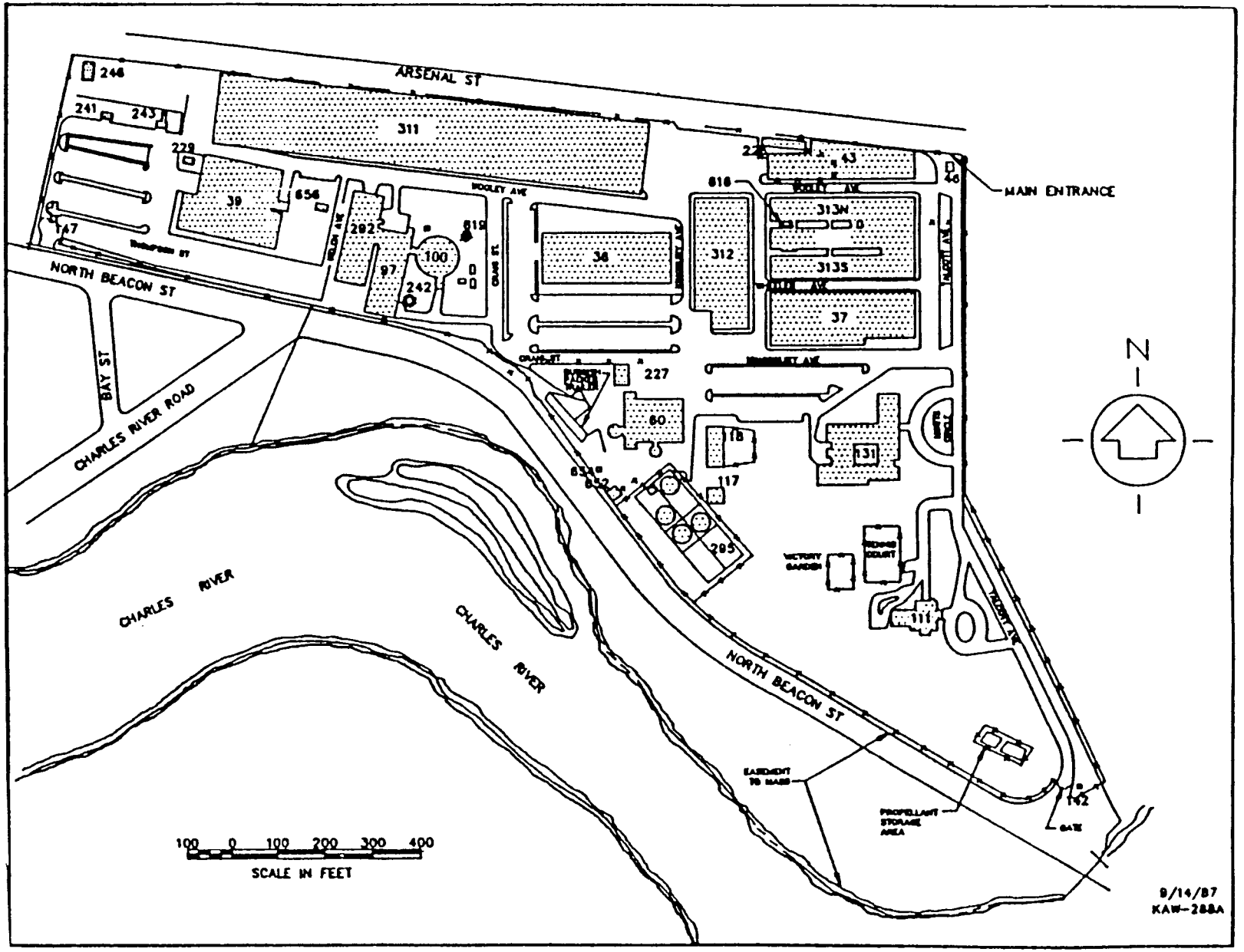


Figure 2. Army Materials Technology Laboratory general site map.

A number of local institutions (Boston College, Worcester Polytechnic Institute, University of New Hampshire, and Massachusetts Institute of Technology) also made use of the AMTL reactor for diffraction measurements and irradiations.

The reactor's license was amended in June 1966 to allow the power level to be increased to 2 MW to provide higher neutron fluxes for experiments. The approach to 2 MW began on June 6, 1966, and was completed on June 15. The procedure that was followed was to increase power in steps of 200 KW and observe all measured parameters for several hours at each step.[3]

The reactor's license was uprated in 1969 from 2 MW to 5 MW. On August 22, 1969, the power-escalation program began and the reactor power was increased in 1 MW steps to the maximum licensed power level of 5 MW. This program was completed with a 79-hour 5 MW run during the week of September 8 with no abnormal results observed during the power-escalation program.[6]

Experiments similar to those described above were planned using the higher power level as well as new experiments for advanced materiel and for research on, development of, and application of composite materials, improved metal alloys, and ceramics.[3,4,5,6]

In December 1969, the Department of the Army decided to shut down the operation of the AMTL reactor and to place the facility in a standby condition in 1970. On March 27, 1970, the reactor operations were shut down and the reactor was placed in a standby mode.[6] A deactivation report was submitted to the Division of Reactor Licensing and to the Army Reactor Systems Health and Safety Review Committee in December 1970.[7]

The following radioactive materials were removed from the reactor building and disposed of as follows:

- The fuel elements containing special nuclear material were removed and returned to the U.S. Atomic Energy Commission.

- The irradiated and unirradiated fuel elements and materials were disposed of under contract with National Lead Company.
- The beryllium oxide (BeO) reflector elements, shim-safety rods, armatures, and stainless-steel pieces from the guide tubes were disposed of as high-activity radioactive waste.
- The fission chambers containing U-235 were transported to another reactor facility and reported under SNM-244.
- The ionization chambers were disposed of as low-level radioactive waste.
- The radioactive sources used for calibration and check of survey meters were transferred to the Army Radiation and Occupational Safety Branch.

The water from the primary and secondary coolant systems, secondary coolant sump, main reactor pool, fuel storage tank (in basement), and Cistern 242 was drained and disposed of.[7] Indications are that the water was monitored for radioactivity and discharged according to standard procedure, which was to either discharge to the sanitary sewer, if found to be below regulatory standards, or to dilute to achieve acceptable release criteria before discharging.

The following liquid-waste system equipment was removed and disposed of from Building 97:

- Three each 3,000-gal decontamination storage tanks
- Disposable ion exchange system
- Pool fill, make-up, and laboratory demineralizer system
- Pumps, valves, and piping associated with the above systems.

The reactor stack, exhaust fan, absolute filter, and the secondary coolant towers were removed and disposed of at a later date.

The major equipment that remains to be disposed of during the decommissioning of the facility is described in the following three paragraphs.

The piping (coolant transfer line, sump pump drain line, demineralized water line, and test connection line) connecting Buildings 97 and 100 is still in place. (The piping between Buildings 97 and 100 is approximately 3-1/2 ft below the surface.)

If total dismantlement of the reactor facility is performed, the utility piping (condensate return line, air line, steam line, and city water line) between Buildings 97 and 100 would also have to be removed.

The stainless-steel pool liner, reactor pedestal, grid plate, and portions of the beam tubes, control rods, and instrument rack remain in the reactor vessel. The top covers for the reactor vessel are also in place. The primary coolant system (heat exchangers, demineralizer systems, pumps and associated piping) remain in the reactor facility basement. The secondary coolant sump, three pumps, and piping to the primary coolant system were also left in place outside the containment shell. Cistern 242 and the associated piping going into Building 97 will also be removed during the decommissioning.

2.2 Background

During the initial criticality, leaks of reactor coolant water through the concrete biological shield were observed. The leaks grew progressively worse and a first attempt to rectify the problem was to drain the annulus and apply glass tape and epoxy resin to all wall and floor joints. All surfaces of the annulus were also finished with epoxy resins. In the annulus there are cavities created by the encasements of concrete over the slant tubes as they pass through the annulus. The concrete encasements had been provided with aluminum drain lines, which passed from the cavities to the main section of the annulus. The drain lines were provided so that no water remained in the cavities when the annulus was emptied. These lines were determined to be leaking and were plugged, which considerably reduced the leakage in the region

where the first balcony is tied to the shield. These efforts to stop the leaks had limited success. Late in 1961, a second attempt was made to stop the leakage by drilling selected holes (2 in. diameter) and pressure-grouting a lean cement mix into the holes. This was unsuccessful because very little grout was accepted by the holes. A chemical grout (AM-9) that could be pumped as a liquid with a preset jelling time was then tried in place of the cement mix and proved to be quite successful. This method, along with the use of pressure-sensitive tape around each beam tube joint, eliminated approximately 75% of the leaks. Some small leaks continued intermittently but did not hamper reactor operations and did not require any special cleanup.[1] In 1966 a stainless-steel liner was installed in the reactor pool and it eliminated the leaks.[4] In 1968 the volume between the stainless-steel liner and the concrete shield was connected by a drain to the basement sump in order to remove any water leakage.[5] The water that leaked through the biological shield did not cause any major contamination spread outside the shield but is suspected of contaminating approximately 50% of the high-density concrete. The water that did reach the reactor basement drained to the main sump.

In 1961, during an unloading of the reactor core, difficulty was experienced in removing some of the BeO reflector elements. An examination revealed that an element had swollen. Further examination indicated that water was leaking into the elements. Since there is no reaction between BeO and water under the operating conditions of the reactor, it was decided that perforated BeO reflector elements could be used.[1] No further difficulties were experienced after modifications were made to reflector elements.

In July 1963 the heat exchanger of the reactor coolant system developed a leak. The heads were pulled and the corroded leaking tube was plugged. Leaks developed on four other occasions and in January 1964 the aluminum tube bundle was removed and replaced. It was determined after examination of the corroded tube bundle and the well water being used that two actions would be initiated to remedy this problem: (1) replace the aluminum bundle with one made from stainless steel and (2) install a recirculating-water cooling tower to provide secondary coolant.[1] These actions were completed in January 1965.[2]

An unplanned release of 4900 gal of radioactive liquid waste occurred from the underground liquid-waste retention tank (Cistern 242) during the period between February 20 and February 27, 1969. The leak was detected after a review of records of the tank level recorder, which indicated that the level of the tank's contents dropped from 15 to 11 ft during this period. Total activity released was 10 μCi as reported by the health physicist. The tank's contents were sampled after the release and the gross activity was determined to be 5.7×10^{-7} μCi/mL. It was concluded by the Reactor Facility Safety Committee that the release was less than 10% of the limit set by 10 CFR 20, Appendix C, for burial of radioactive waste in the soil.[8]

Between January 1, 1969, and March 27, 1970, there were 62 unscheduled shutdowns of the reactor. In many instances, no direct cause was readily apparent, as the shutdown would manifest itself as a single rod dropping without any evidence of malfunction or unsafe condition. The majority of these unexplained rod drops were believed to be caused by noise in the period safety channel, which momentarily reduced the magnet current below the drop current.[6]

Based on the information contained in the operations reports of the U.S. Army Materials Research Agency Nuclear Reactor Facility covering the period from June 15, 1960, through March 27, 1970,[1,2,3,4,5,6] and a review of the facility safety reports, there are no indications that any fuel was breached during reactor operations or fuel transfers between the reactor core and the annulus. Further evidence that no fuel was breached are the low levels of radioactivity and contamination found in the reactor vessel and on the reactor internal components.

3. FACILITY DESCRIPTION

3.1 Building 100, Reactor Containment Building

Building 100, the reactor containment structure (see Figure 3), is a cylindrical pressure vessel 80 ft in diameter, approximately 67 ft high from ground level, with an elliptical top. A cross-section of the containment shell is shown in Figure 4. The basement foundation is approximately 19 ft below ground-level and a 6-ft-diameter gamma-ray facility extends an additional 9 ft below the foundation level. The perimeter walls of the gas-tight containment shell are 2-ft-thick concrete and extend up to the crane rails 44 ft above ground level. The above-ground walls and the roof are covered with a 1/2-in. welded steel plate. There are two large penetrations in the perimeter wall for personnel airlocks permitting access to the interior of the shell. The electrical utilities are brought in through seals which consist of a conduit box filled with a sealant and a metal tube welded to the shell which allows the electrical cables to pass through the containment shell. The water inlet lines (city water and secondary cooling water) and outlet lines (liquid waste and secondary cooling water) pass through pipes welded to the shell. The air, steam, return condensate, and demineralized water lines also enter the containment shell from Building 97 through pipes welded to the steel shell. Air inlet and outlet is accomplished through steel ducts with flanges welded to the shell and provided with automatic closing dampers. Overpressurization protection for the shell is provided by a 2-in. line with a water trap equivalent to a 5-ft head of water installed between the shell and the atmosphere. The containment shell completely encloses the reactor and all of its associated equipment with the exception of Cistern 242 and the secondary coolant pump pad.

The bottom of the basement floor is approximately 19 ft below grade. The groundwater in the area of the reactor building is apparently 14 to 16 ft below grade. During decommissioning (assuming total dismantlement) when the basement floor is excavated and removed, routine practices will be used to minimize any contamination spread to the groundwater in the event that contamination exists beneath the basement floor.

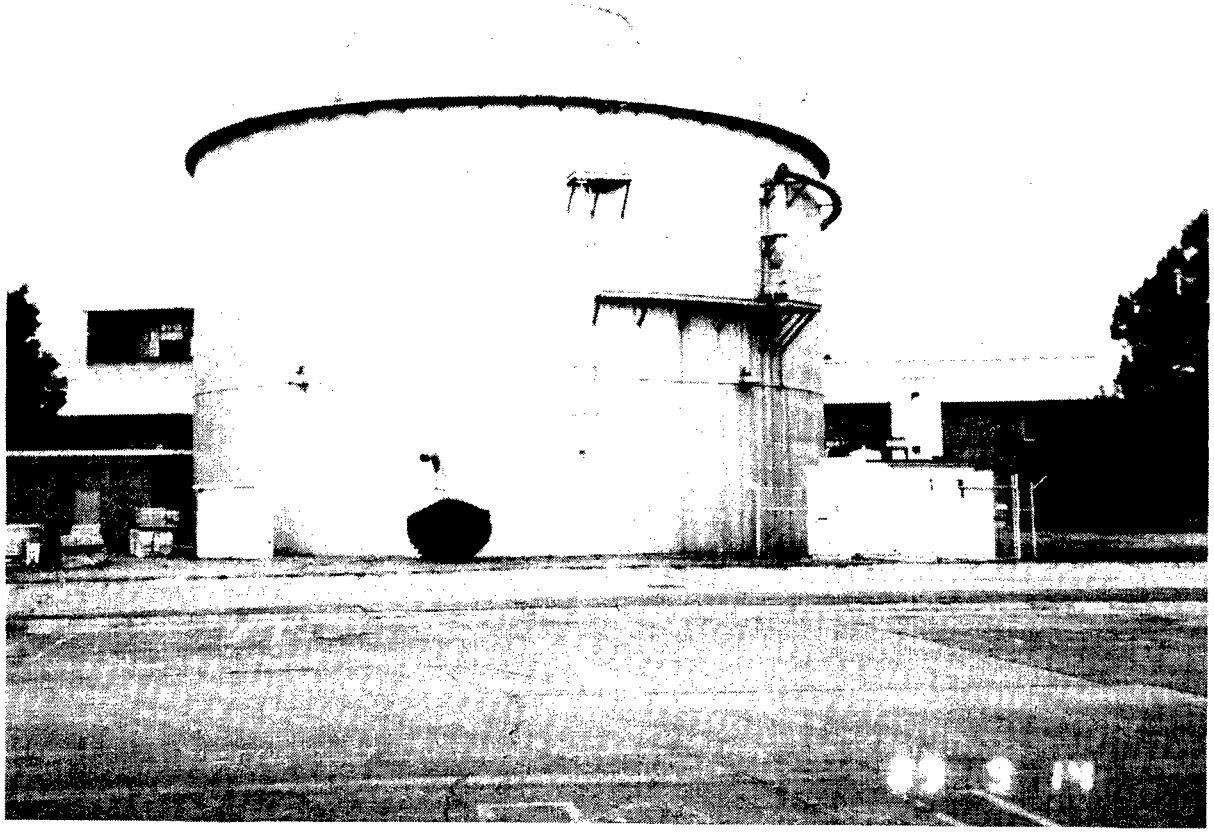
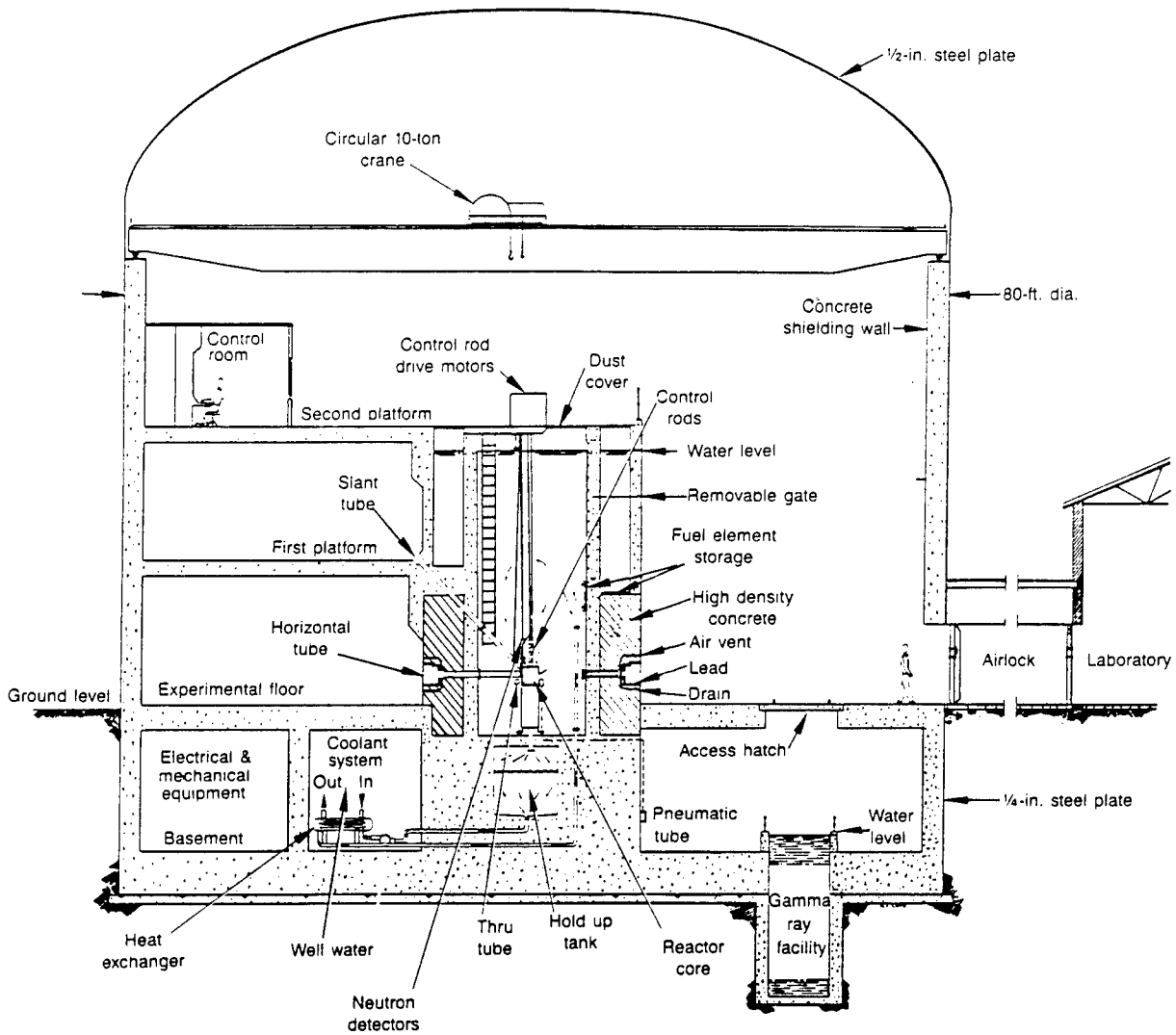


Figure 3. View of Building 100, looking west. Building 97 is in the background.



Containment Shell

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Figure 4. Reactor containment-shell cross-sectional view.

The containment-shell floor plans are shown in Figure 5. The main operating floor, which is at ground level, is about 76 ft in diameter and is completely free for experimental use with the exception of the stairways and necessary equipment. The first platform provided access to the six slant beam tubes which exit at this level from the reactor vessel. The second platform provided an area for the reactor control room and space for personnel and equipment for loading and unloading the reactor. A standard 10-ton crane, mounted on a circular track, was used to service the main floor, the platforms, and part of the basement through floor openings.

The basement area was used for experimental and operational purposes. A gamma-ray exposure experimental facility was built below the basement floor level. The gamma-ray facility could also be used for fuel storage. There are 16 vertical storage tubes in one part of the basement floor that could be used for storage of radioactive materials, such as beam tube plugs, collimators, and irradiated samples. These 16 vertical tubes are 4 ft 3 in. deep. Two tubes are 12 in. in diameter, two are 10 in. in diameter, eight are 8 in. in diameter, and four are 4 in. in diameter.

All the primary-coolant equipment for the operation of the reactor is located in the basement and is separated from occupied areas by 2-ft-thick, ordinary concrete walls. A main sump is also located in the basement to which all liquid waste within the containment shell drained. The liquid waste was then automatically pumped to a liquid-waste storage tank, which was part of the liquid-waste handling system that was located in Building 97 before its removal.

The reactor is a version of the "swimming pool" type with the pool having been replaced by an octagonal open tank, completely above ground. The internal dimensions of the tank are 10-1/2 ft in diameter by a depth of 30 ft, which provided 4 ft of water shielding from the fuel horizontally and 22 ft of water shielding above the centerline of the fuel vertically. The concrete biological shield consists of approximately an inner 16 in. of ordinary concrete and 4 ft of high-density concrete.

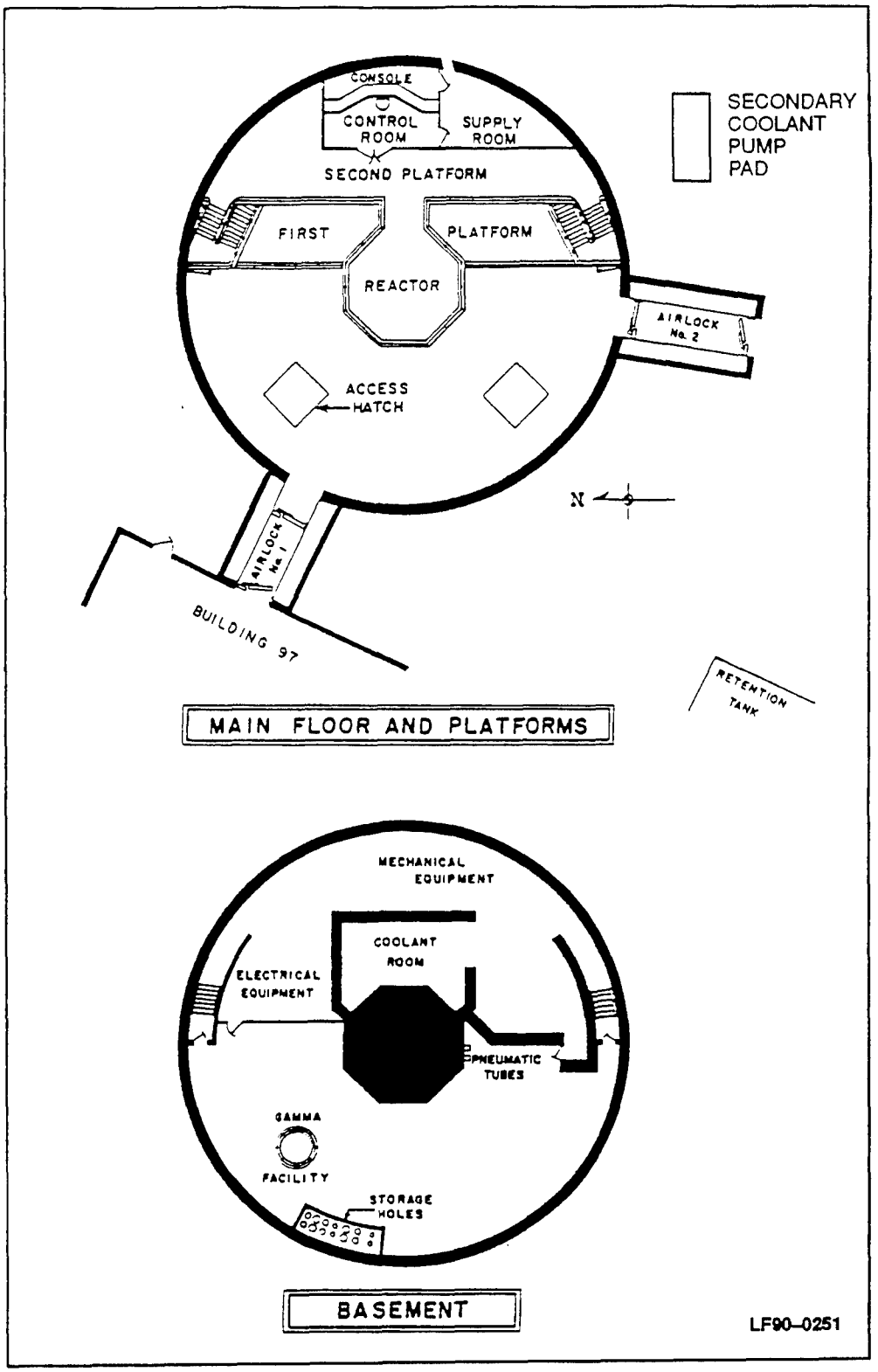

Figure 5. Reactor containment-shell floor plans.

Maximum neutron beam facilities were utilized by the addition of 16 horizontal 6-in. beam tubes, one horizontal 6-in. through tube, and six slant 6-in. beam tubes. See Figure 6 for a three-dimensional model of the reactor.

A cover made up of hinged metal plates closed off most of the top of the pool. This allowed access to the pool for transfer of fuel elements between the reactor and the lead-lined recessed storage positions available in the annulus. The annulus was built around the upper portion of the reactor pool and is accessible from the pool through a removable, watertight gate which permitted the movement of fuel elements under water.

The fuel elements used in the open-top, tank-type, thermal, heterogeneous, H_2O-cooled and moderated reactor were Materials Testing Reactor-type assemblies fitted into a grid plate and expanded to a 7 x 9-in. array. The increase in grid-plate size permitted changes of core configuration, as well as providing the greater fuel loading needed to overcome reactivity losses to the beam tubes and for operation at higher power levels. The reactor grid plate is supported on a pedestal on the bottom of the pool as shown in Figure 7.

3.2 Building 97, Reactor Facility Laboratory

The reactor facility included portions of Building 97, which provides access to Building 100 through an airlock and contained offices and laboratories for support of the reactor operations (see Figure 3). The liquid-waste handling system for the reactor was also contained in the south end of this building. This system consisted of three above-ground 3000-gal waste water storage tanks and a disposable cation, anion and mixed ion exchange system for storing and treating contaminated water from the reactor. Contaminated water stored in the retention tank, Cistern 242, could also be pumped to this system for processing. The three storage tanks, mixed ion exchange system, and pool fill, make-up, and laboratory demineralizer system were removed after deactivation of the reactor to make room for a particle accelerator.

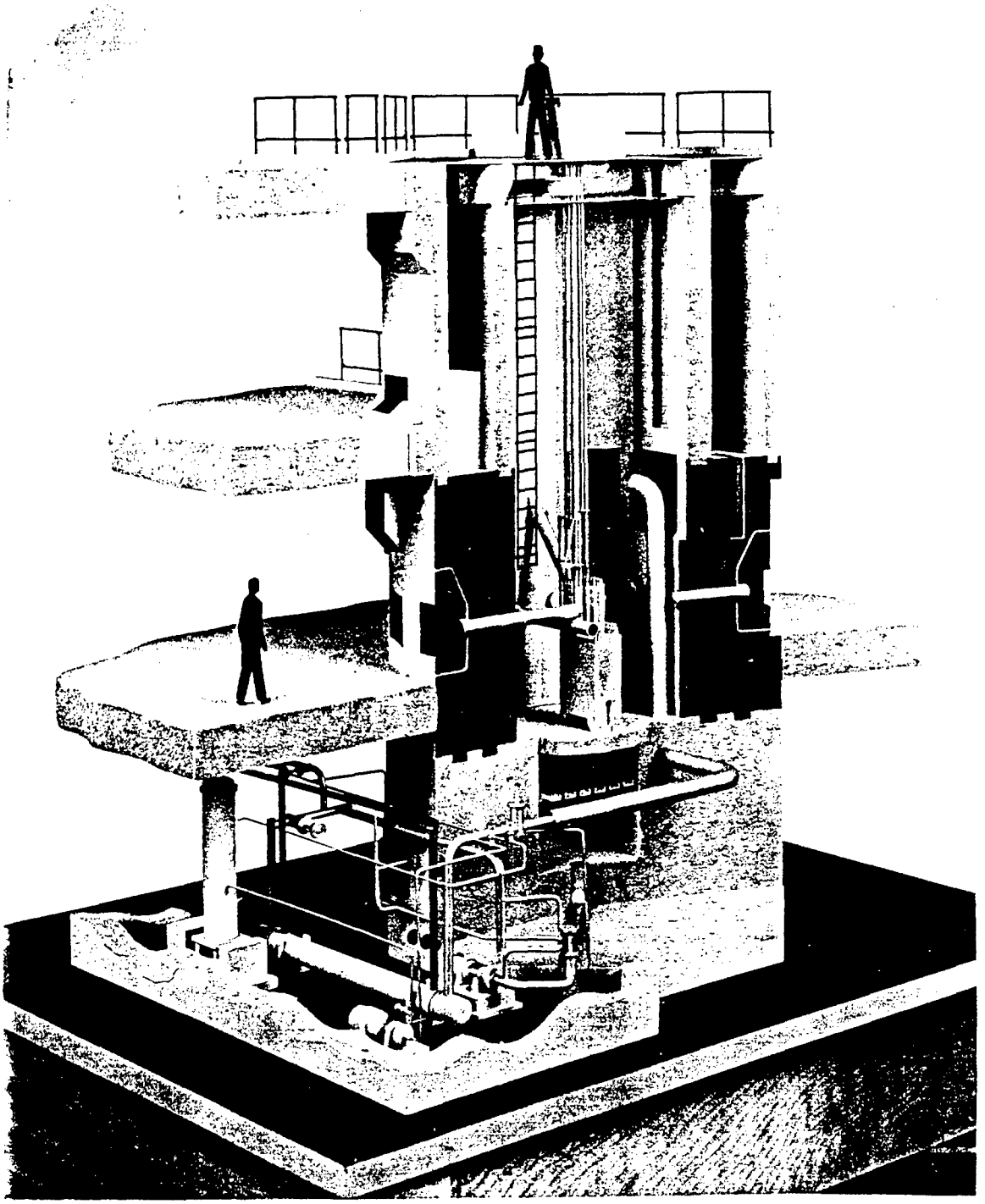

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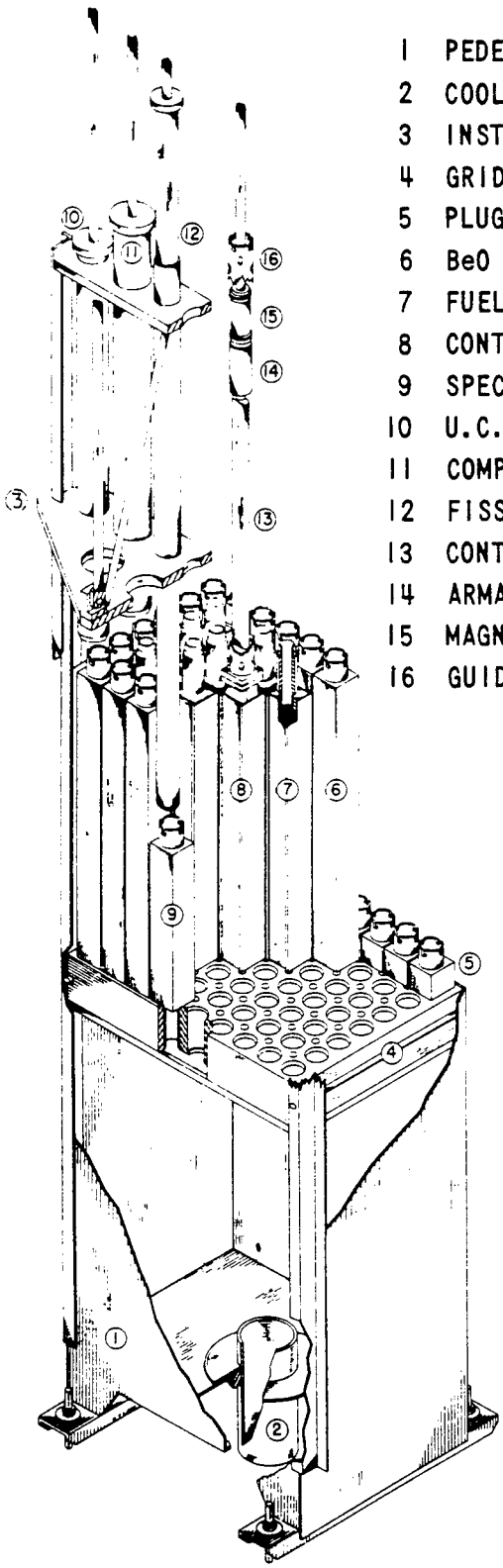
Figure 6. Army Materials Technology Laboratory Research Reactor model.



1 PEDESTAL
2 COOLANT SUCTION
3 INSTRUMENT RACK
4 GRID PLATE
5 PLUG
6 BeO REFLECTOR ELEMENT
7 FUEL ELEMENT
8 CONTROL ROD FUEL ELEMENT
9 SPECIAL REFLECTOR ELEMENT
10 U.C. ION. CHAMBER
11 COMP. ION. CHAMBER
12 FISSION CHAMBER
13 CONTROL ROD
14 ARMATURE
15 MAGNET
16 GUIDE TUBE

Figure 7. Reactor core support.

Only the portion of the piping described in Section 3.1 that remains between Buildings 97 and 100 and to Cistern 242 will be addressed in this report. Building 97 presently contains chemistry laboratories, an ion-implantation facility, and a particle accelerator for neutron production.

3.3 Cistern 242, Waste Water Retention Tank

A buried retention tank, Cistern 242, located approximately 25 ft southwest of Building 100, served as the low-level waste storage tank for the reactor (see Figure 8). The 23-1/2 ft square tank is constructed of 1-ft-thick concrete and is 15 ft deep. A manhole cover provides access to the tank's interior. The tank was used to hold the reactor pool water during reactor maintenance to minimize the time and expense of supplying demineralized water to refill the pool. If the reactor pool water had become seriously contaminated, it could also have been pumped to the retention tank. The contaminated water could then be processed in the liquid-waste handling system located in Building 97. In October 1966 a liquid-level-indicating recorder was installed to facilitate waste management and to provide a method of monitoring the retention tank for any appreciable leakage.[3] The water contained in the retention tank was drained and the tank flushed to the sewer system after the reactor was deactivated.

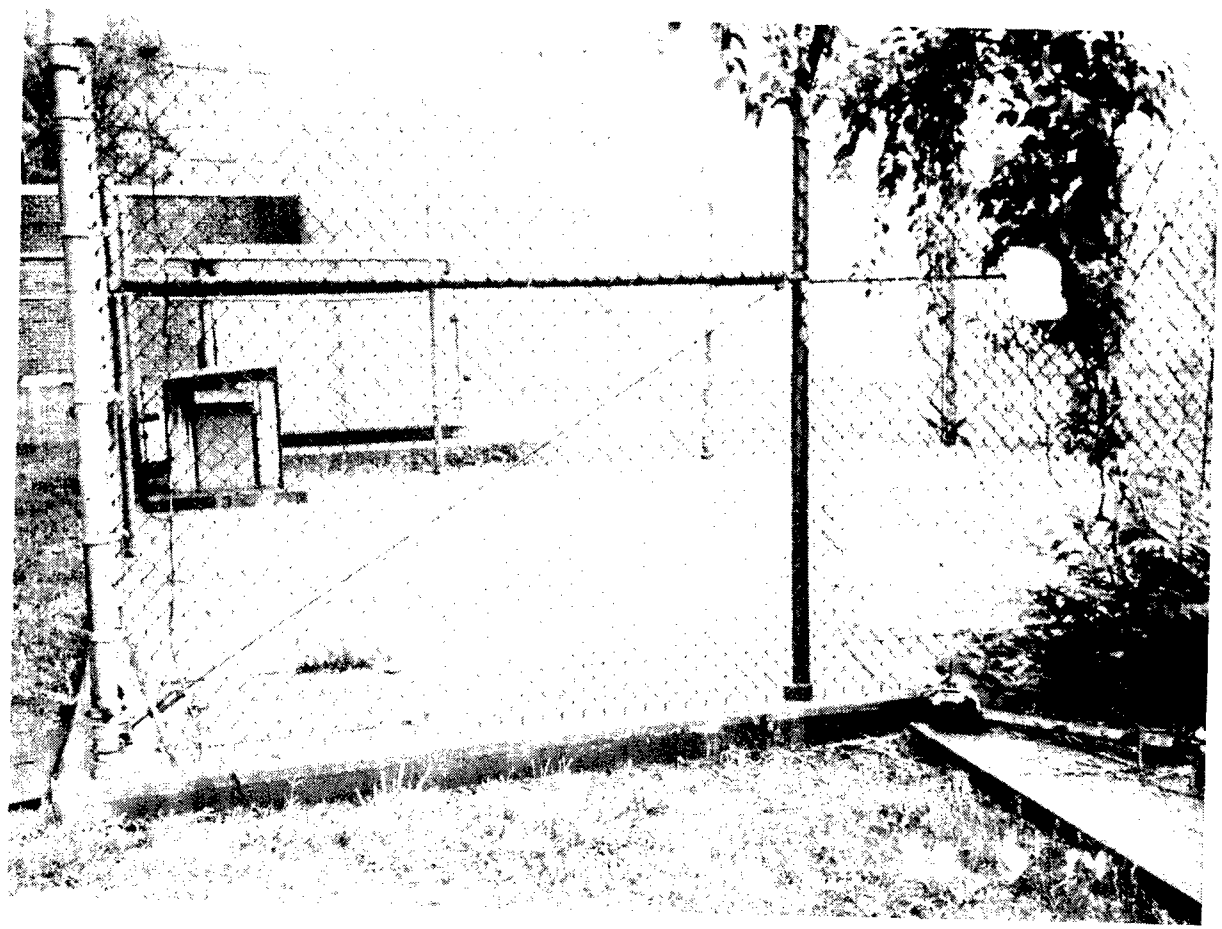


Figure 8. View of Cistern 242, looking north. Building 100 is in background.

4. CHARACTERIZATION

In September 1989, radiological surveys were conducted in Building 100, the reactor containment, to characterize the reactor facility for future decommissioning.

The water in Cistern 242 was sampled during February 1990 and the results indicated that the radioactivity levels were well below the drinking-water standards. AMTL was requested to remove the water from the cistern in order that the cistern's interior could be sampled in March when additional soil sampling was to be performed.

During March 1990, sediment and soil samples were collected at the surface and subsurface from locations around Building 100 and Cistern 242 to determine the presence of any metals, lead, mercury, Appendix IX analytes, alpha-emitting nuclides and gamma-emitting nuclides. Smears were also collected from piping located in Building 97, which housed the liquid-waste handling system, to determine the levels of radioactive contamination. The interior of Cistern 242 was not sampled during this sampling trip. Local regulatory authorities are still reviewing information submitted by AMTL and requests to remove the water in order to allow access to the tank interior.

Details of the results of sampling efforts are contained in Sections 4.1 through 4.4 and the associated figures and tables.

4.1 Building 100, Reactor Containment Building

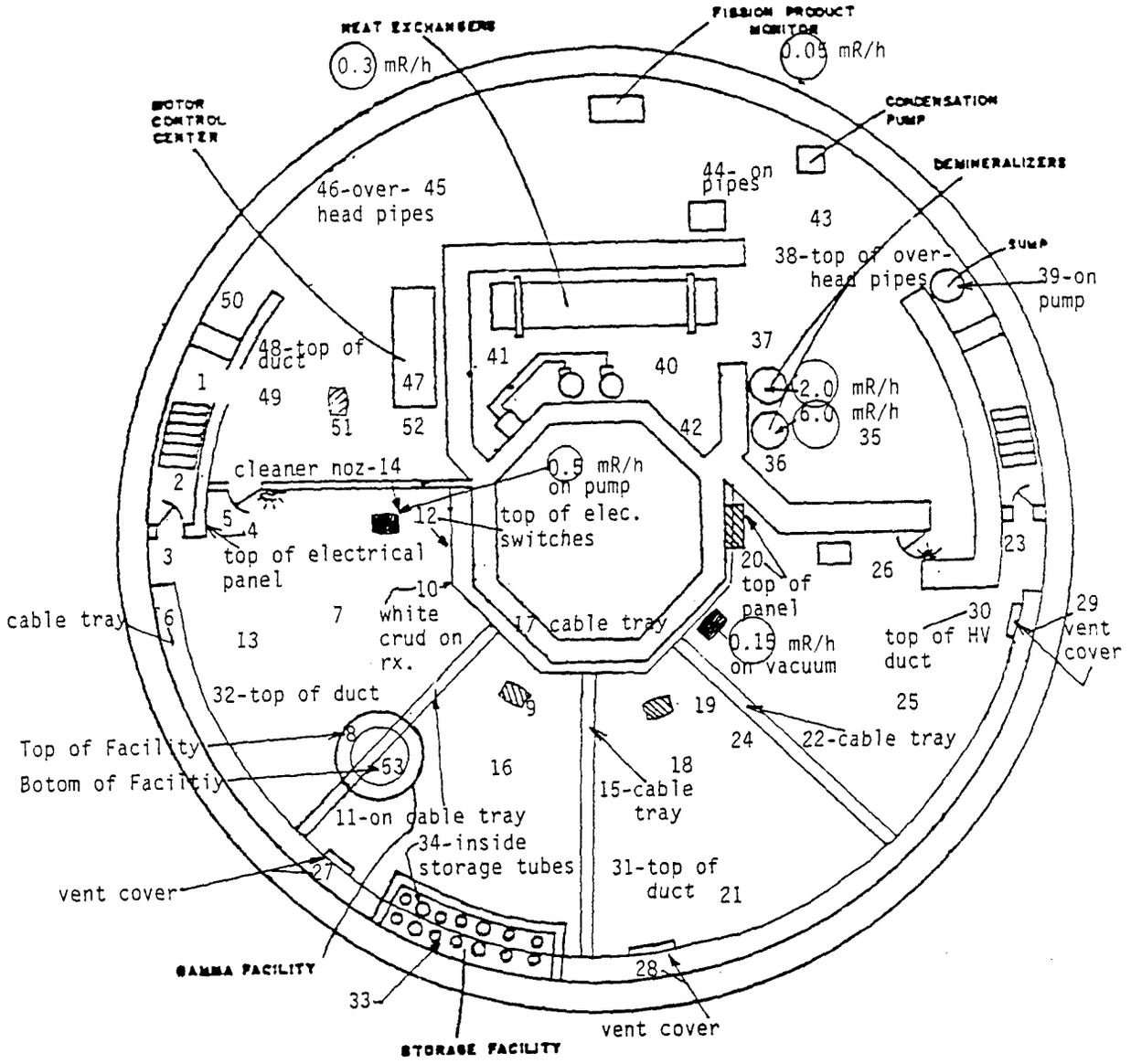
EG&G personnel conducted radiological surveys of the inside of the deactivated reactor containment building from September 11-15, 1989. Areas surveyed inside the building were as follows: the basement, the operations floor, the first and second platforms, the reactor control room (located on the second platform), the top of the reactor, the reactor vessel, the reactor pedestal and the reactor annulus.[9]

All radiation measurements were made with portable beta-gamma radiation instruments with detection efficiencies of 10%. Detection efficiency relates instrument output to radiation input. For example, an instrument with an efficiency of 10% that receives radiation of 1000 disintegrations per minute (dpm), would read 100 counts per minute. The smears that were collected were counted at the INEL with a decade scaler. These instruments were utilized for all the areas surveyed.

All smears taken and analyzed for the reactor basement area except smear number 34 were less than the most restrictive part of NRC Regulatory Guide 1.86, which gives acceptable surface contamination levels. The acceptable levels for removable contamination are: less than 200 dpm/100 cm^2 beta-gamma and less than 20 dpm/100 cm^2 alpha. Smear number 34 was collected inside the storage tubes of the storage facility and read 293 dpm/100 cm^2 beta-gamma and less than 20 dpm/100 cm^2 alpha. Figure 9 shows in detail the location and number of each smear taken and contact-radiation readings (circled) in areas where readings could be detected in the basement.

Figures 10, 11, and 12 show the location and number of each smear taken and the contact-radiation readings (circled) in areas where readings could be detected for the operating floor and the first and second platforms, respectively. Smears obtained and analyzed for these areas were all less than 200 dpm/100 cm^2 beta-gamma and less than 20 dpm/100 cm^2 alpha.

Figures 13, 14, and 15 provide the locations, numbers, and results of smears taken in the reactor annulus. Contact-radiation readings are also shown for areas with the highest activities. The results of an isotopic gamma scan, performed on one of the more contaminated smears from the reactor annulus, showed europium-152 (Eu-152), Eu-154, and cobalt-60 (Co-60) in the amounts shown in Table 1.



BASEMENT

Note: Contact-radiation readings are circled.

Figure 9. Smear survey locations for reactor basement.

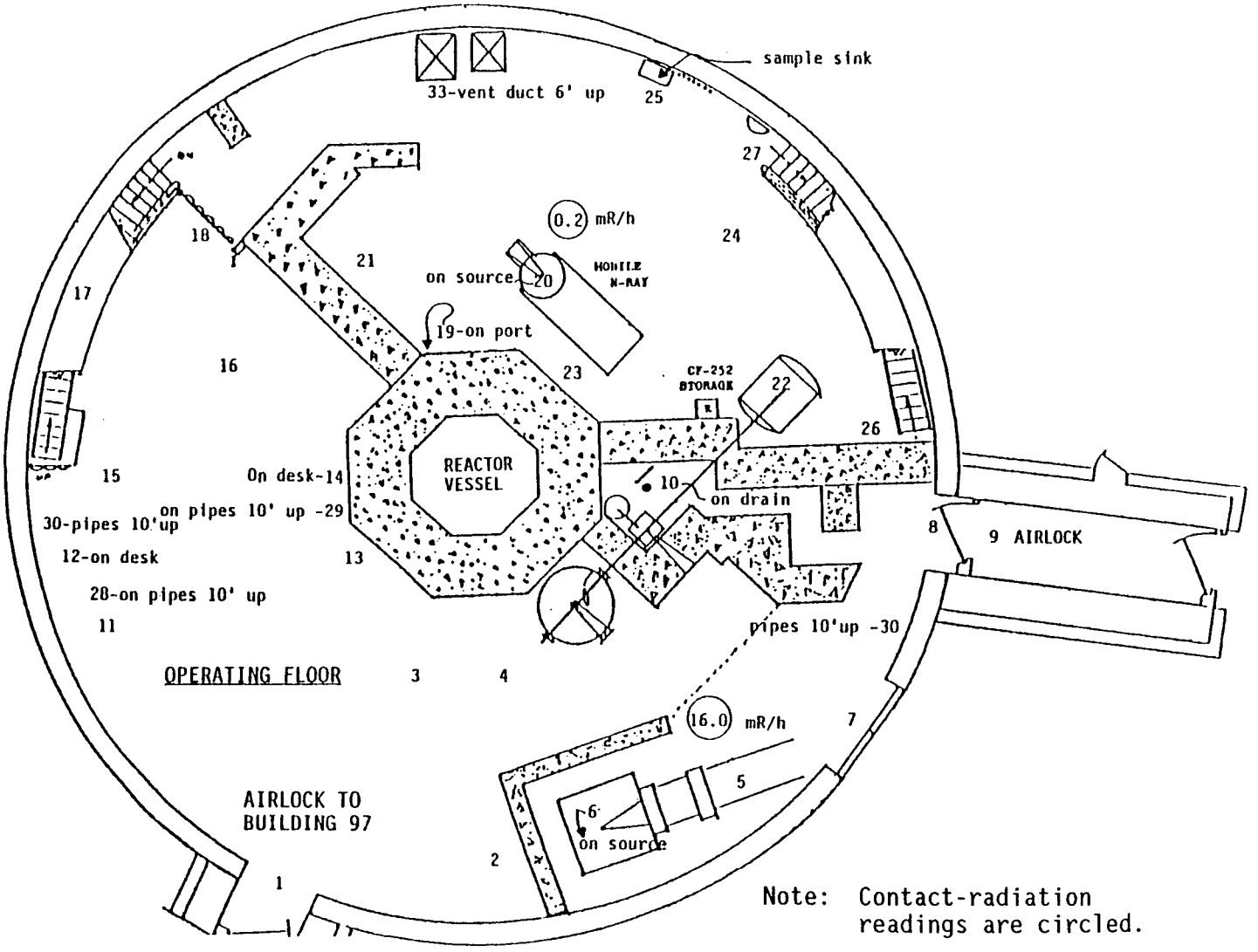


Figure 10. Smear survey locations for reactor operating floor.

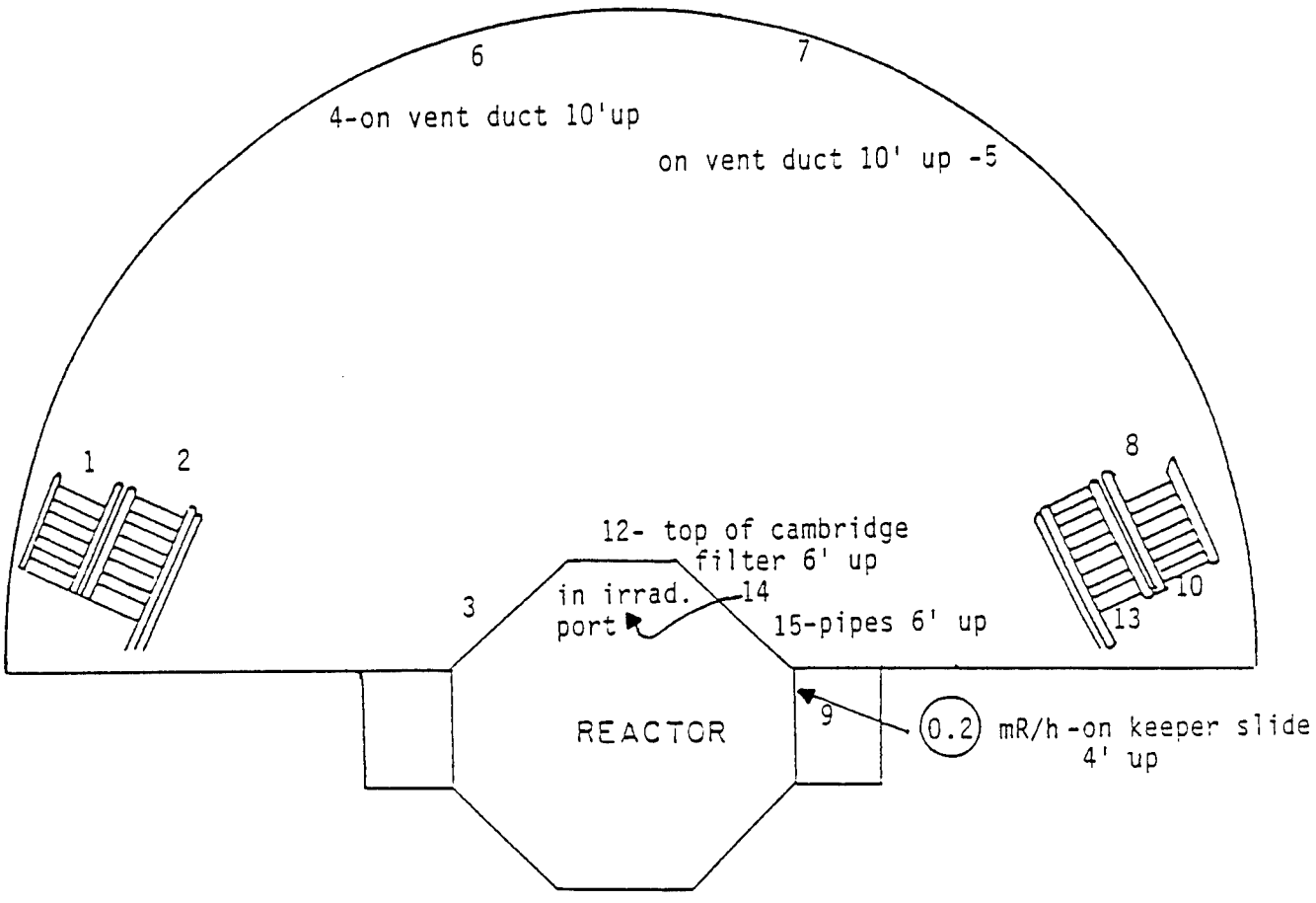
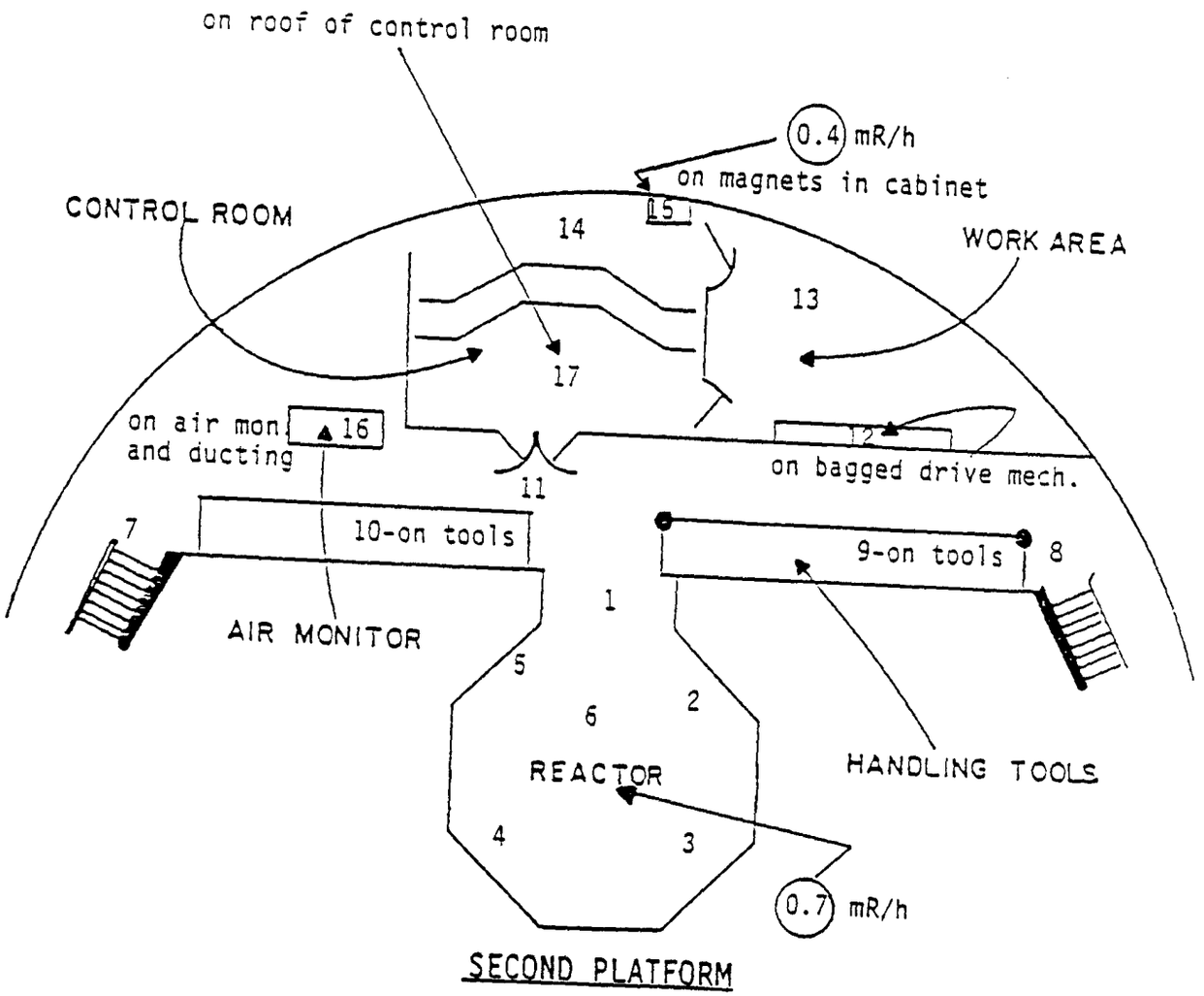


Figure 11. Smear survey locations for reactor first platform.



Note: Contact-radiation readings are circled.

Figure 12. Smear survey locations for reactor second platform.

Smear No.	Beta-Gamma (dpm/100 cm²)	Alpha (dpm/100 cm²)
1	<200	<20
2	359	<20
3	335	<20
4	293	<20
5	395	<20

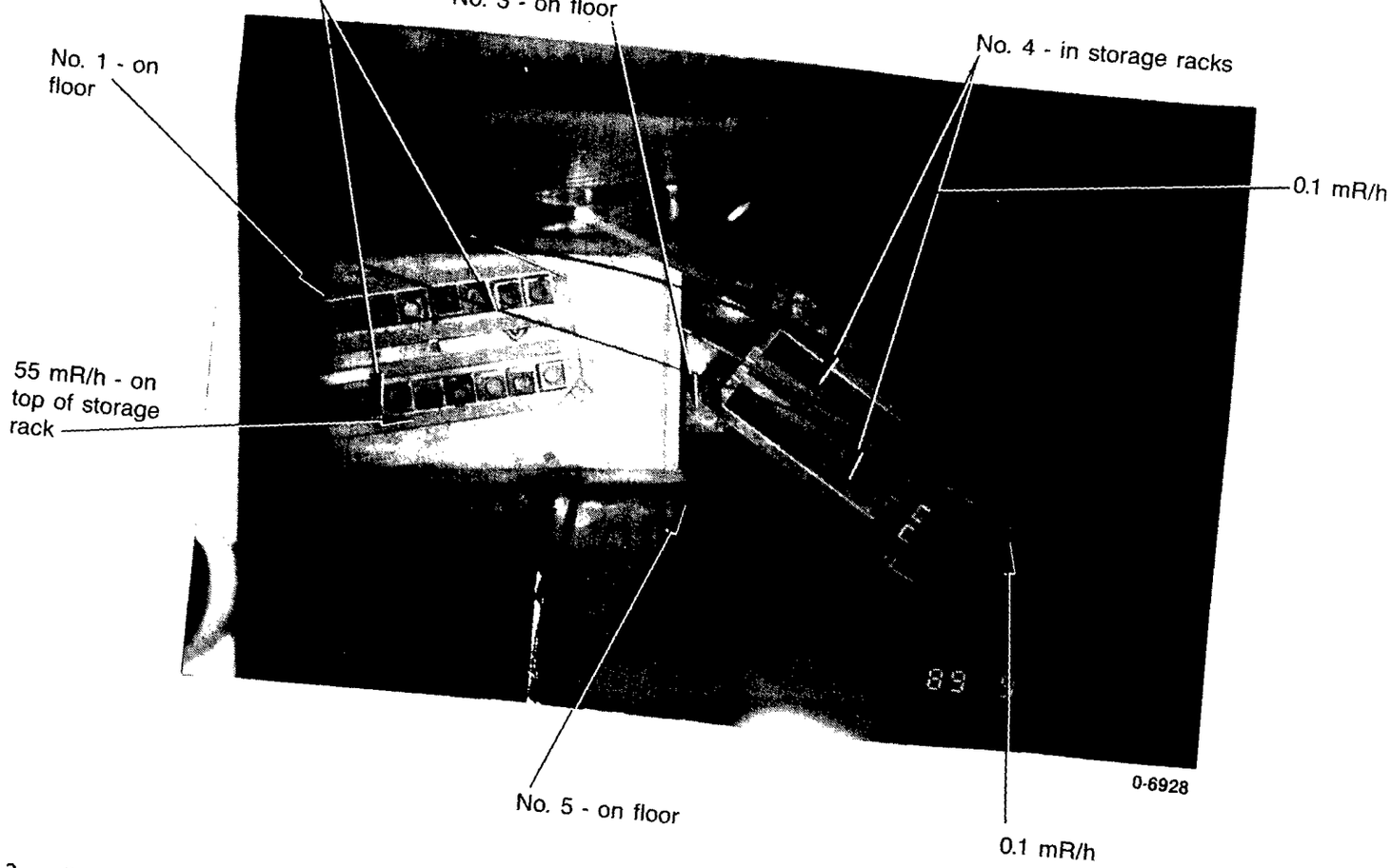


Figure 13. Smear survey results and contact-radiation readings for reactor annulus fuel element storage.

Smear No.	Beta-Gamma (dpm/100 cm²)	Alpha (dpm/100 cm²)
6	Lost	Lost
7	749	<20
8	5707	<20
9	755	<20

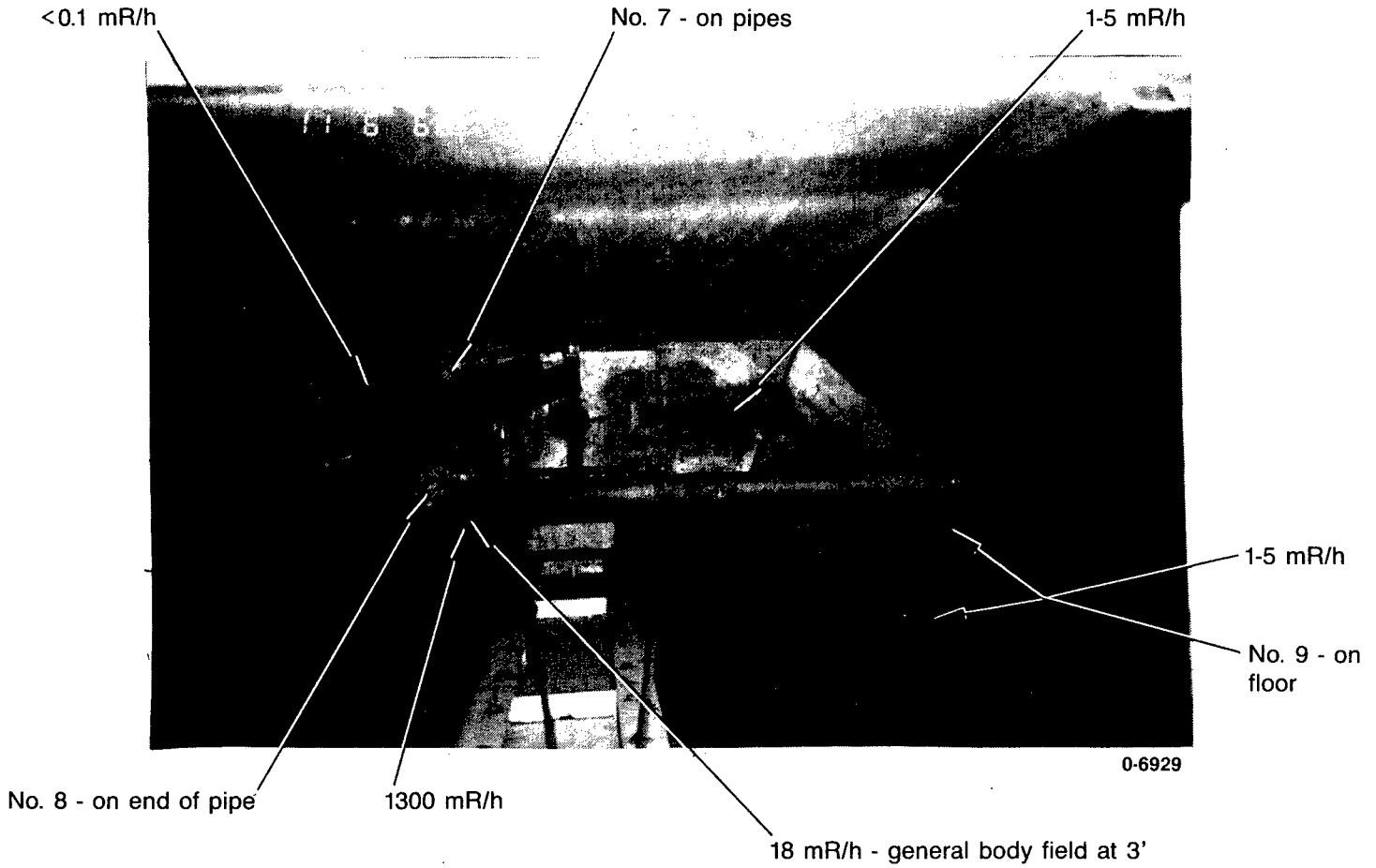


Figure 14. Survey results and contact-radiation readings for reactor annulus components.

Smear No.	Beta-Gamma (dpm/100 cm²)	Alpha (dpm/100 cm²)
10	725	<20
11	240	<20

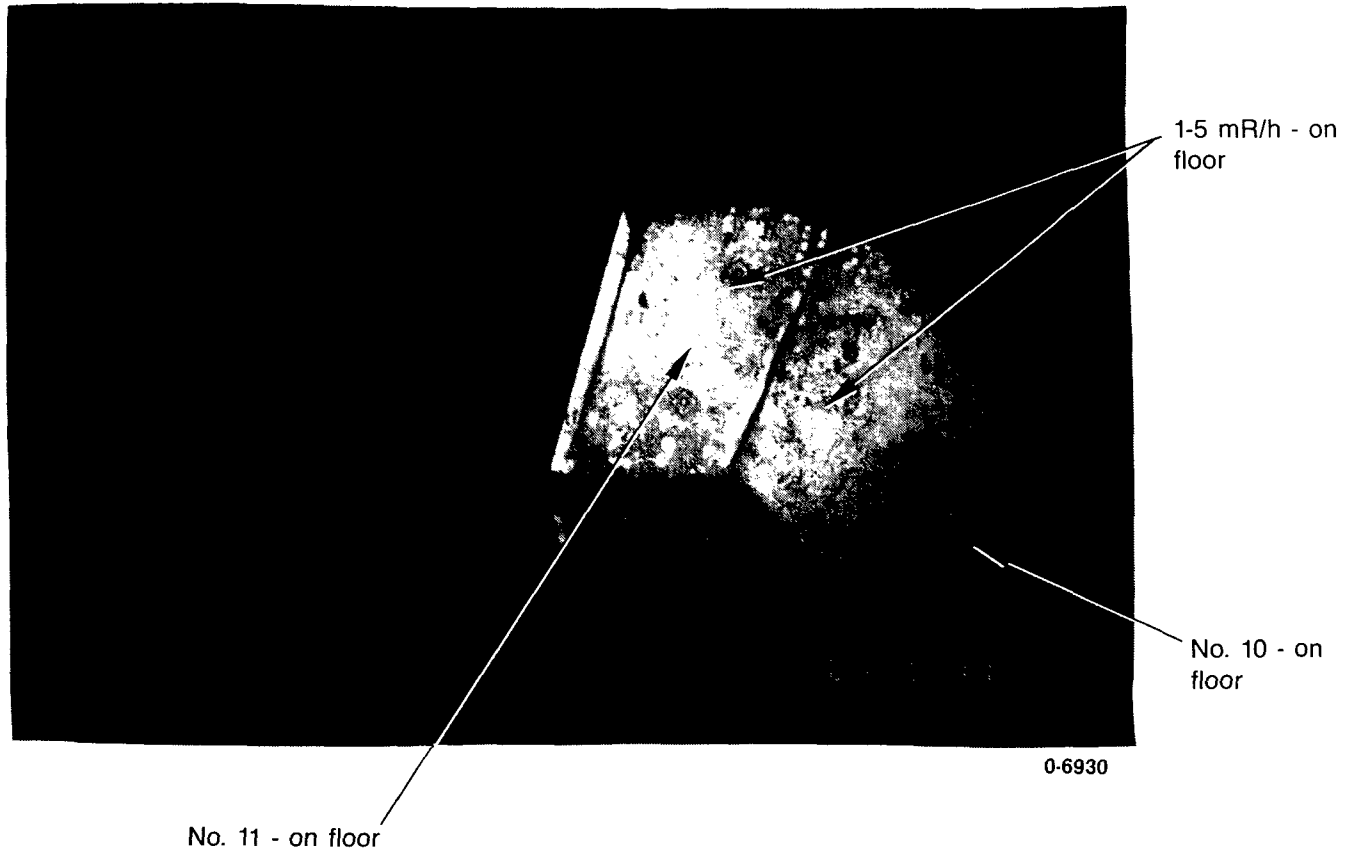


Figure 15. Smear survey results and contact radiation readings for reactor annulus floor.

Table 1. Results of Isotopic Gamma Scan for Annulus Smear Sample

SAMPLE NAME:	ANNULUS SMEAR
SAMPLE ID:	112189023
SAMPLE COLLECTION (DATE/TIME):	112189/1241
SAMPLE COUNTED (DATE/TIME):	112189/1241
SAMPLE QUANTITY:	1.0

NOTE: The percent error shown for each radionuclide is the statistical/fitting component obtained from weighted results of all photopeaks found for the nuclide. Other error components that should be considered in the total error are detector efficiency (5.0%), geometry/positioning (5.0%), and any other errors that can be quantified (0.0%).

RADIONUCLIDE	SAMPLE ACTIVITY (μCi/100 cm^2)	% ERROR (1-Σ)
Co-60	1.016E-03	2.52
EU-152	4.848E-04	3.76
EU-154	8.500E-05	22.56

Figures 16, 17, and 18 provide the location of contact-radiation readings taken internally in the reactor vessel. Figures 18, 19, and 20 provide the locations, numbers, and results of smears taken in the reactor vessel. Water samples, believed to be primary water, obtained from the reactor beam tubes contained no measurable activity.

Table 2 provides a summary of the smear sampling, and Table 3 provides a summary of the radiation survey conducted in the reactor building. Based on these surveys it appears that only the reactor annulus and some of the reactor components are contaminated. Transuranic isotopes were not detected on any of the smears but, as shown in Table 1, Eu-152, Eu-154, and Co-60 isotopes were detected. The highest radiation readings were measured on components contained within the reactor annulus and vessel.

4.2 Building 97, Reactor Facility Laboratory

Building 97 originally contained the liquid-waste handling system for the reactor. This system was removed to make room for a particle accelerator, as discussed in Section 3.2. All that presently remains is the piping (4-in. iron coolant transfer line, 2-1/2-in. iron sump pump drain line, 2-in. aluminum demineralized water line, and 1-in. iron test connection line) connecting Buildings 97 and 100. If total dismantlement of the reactor facility is performed, the utility piping (1-1/2-in. iron condensate return line, 2-in. galvanized steel air line, 4-in. iron steam line, and 4-in. iron city water line) between Buildings 97 and 100 would also have to be removed. The portion of this piping between buildings is approximately 3-1/2 ft below the surface. The condensate return and steam lines are encased in asbestos coverings. (Some of the asbestos has been removed.) Smears taken from the piping inside Building 97 indicate that the radioactivity levels are less than 200 dpm/100 cm^2 beta-gamma and less than 20 dpm/100 cm^2 alpha. The piping (2-1/2-in. iron outlet line, 4-in. iron inlet line, and 4-in. cast iron overflow line) to Cistern 242 is mostly inaccessible since it is underground and will be surveyed during the decommissioning of the facility. The inlet and outlet pipes are buried 5-1/2 ft deep and the overflow pipe is buried 3-1/2 ft deep.

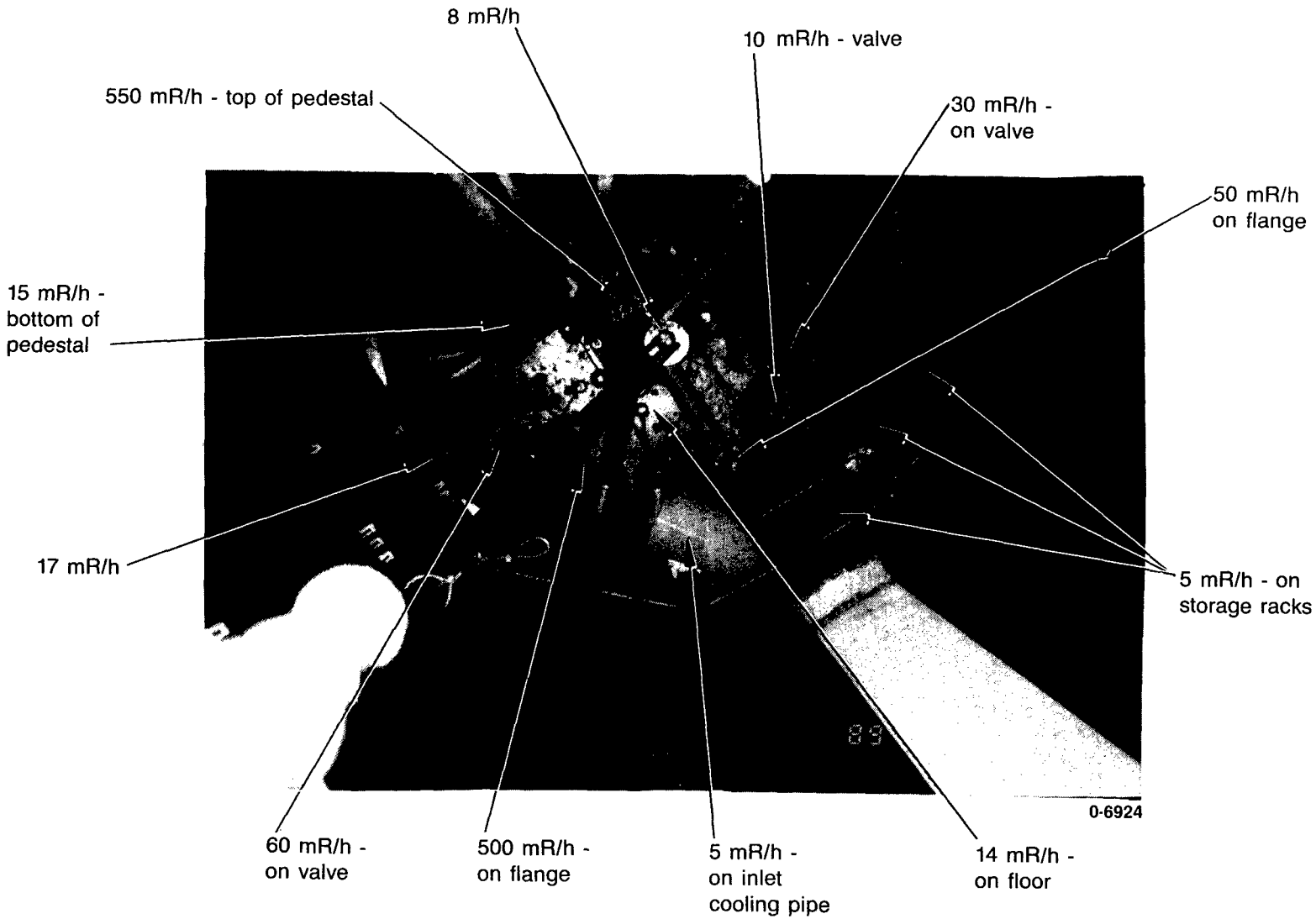


Figure 16. Contact-radiation readings for internal components of reactor vessel (View No. 1).

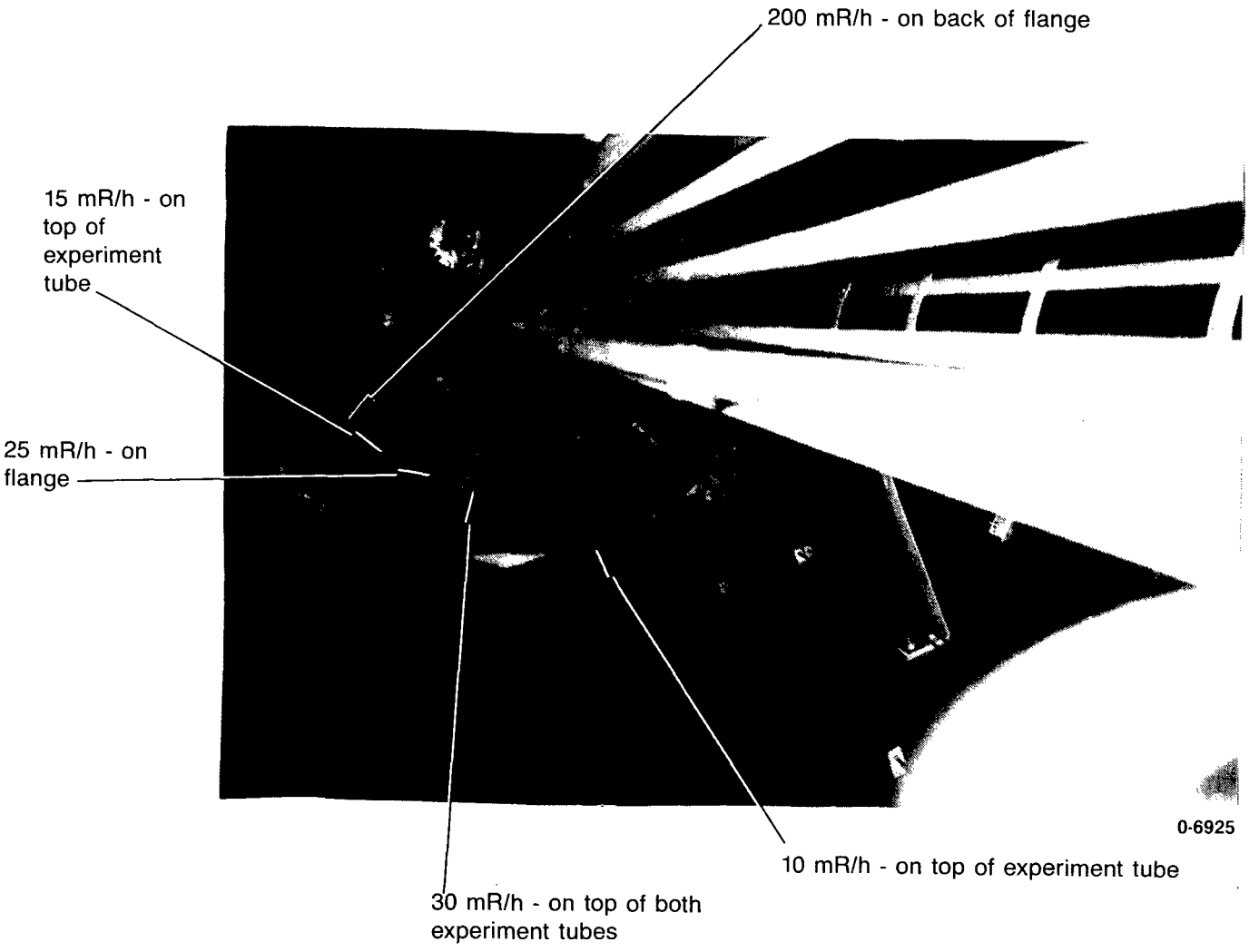


Figure 17. Contact-radiation readings for internal components of reactor vessel (View No. 2).

Smear No.	Beta-Gamma (dpm/100 cm²)	Alpha (dpm/100 cm²)
1	<200	<20
2	<200	<20
12	<200	<20

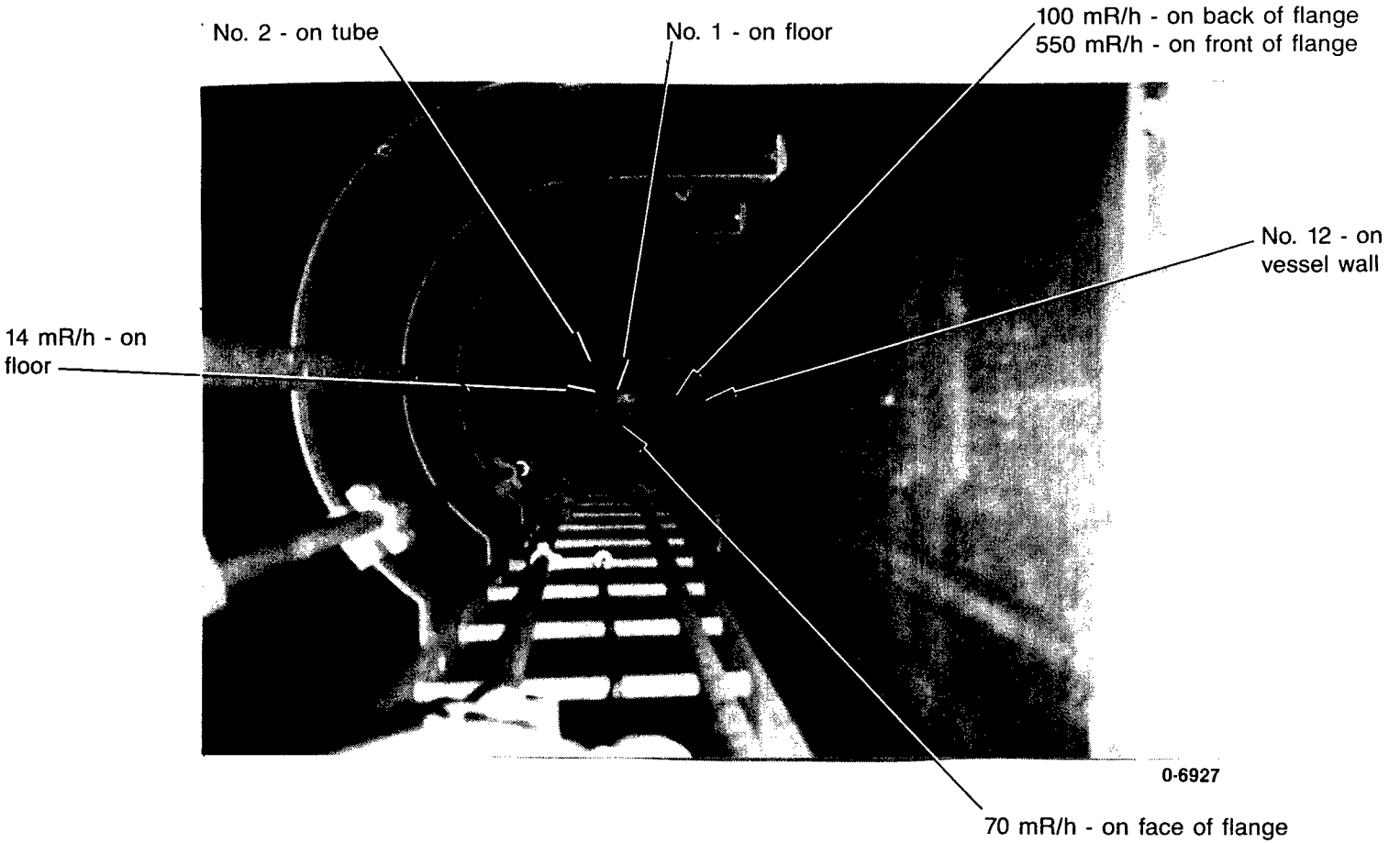


Figure 18. Contact-radiation readings and smear survey results for internal components of reactor vessel (View No. 3).

Smear No.	Beta-Gamma (dpm/100 cm²)	Alpha (dpm/100 cm²)
3	204	<20
4	<200	<20
5	<200	<20
6	<200	<20
7	<200	<20

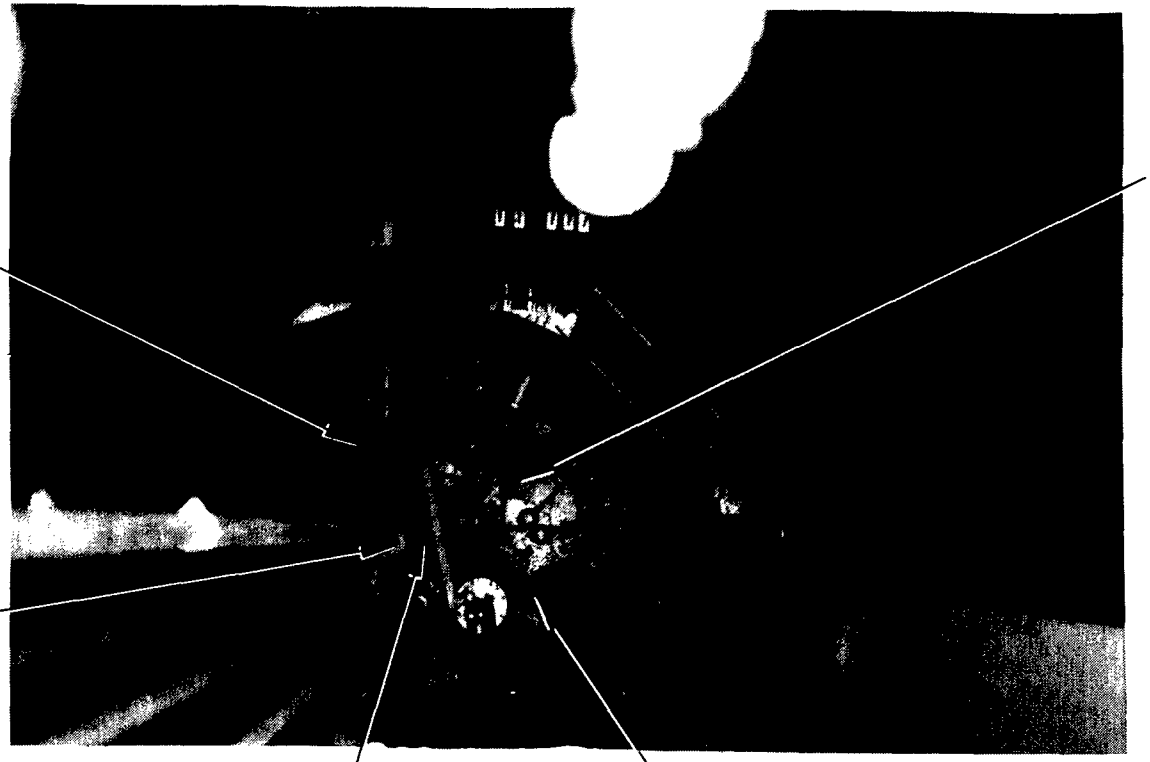


Figure 19. Smear survey results for internal components of reactor vessel (View No. 1).

Smear No.	Beta-Gamma (dpm/100 cm²)	Alpha (dpm/100 cm²)
8	<200	<20
9	<200	<20
10	<200	<20
11	<200	<20
13	<200	<20

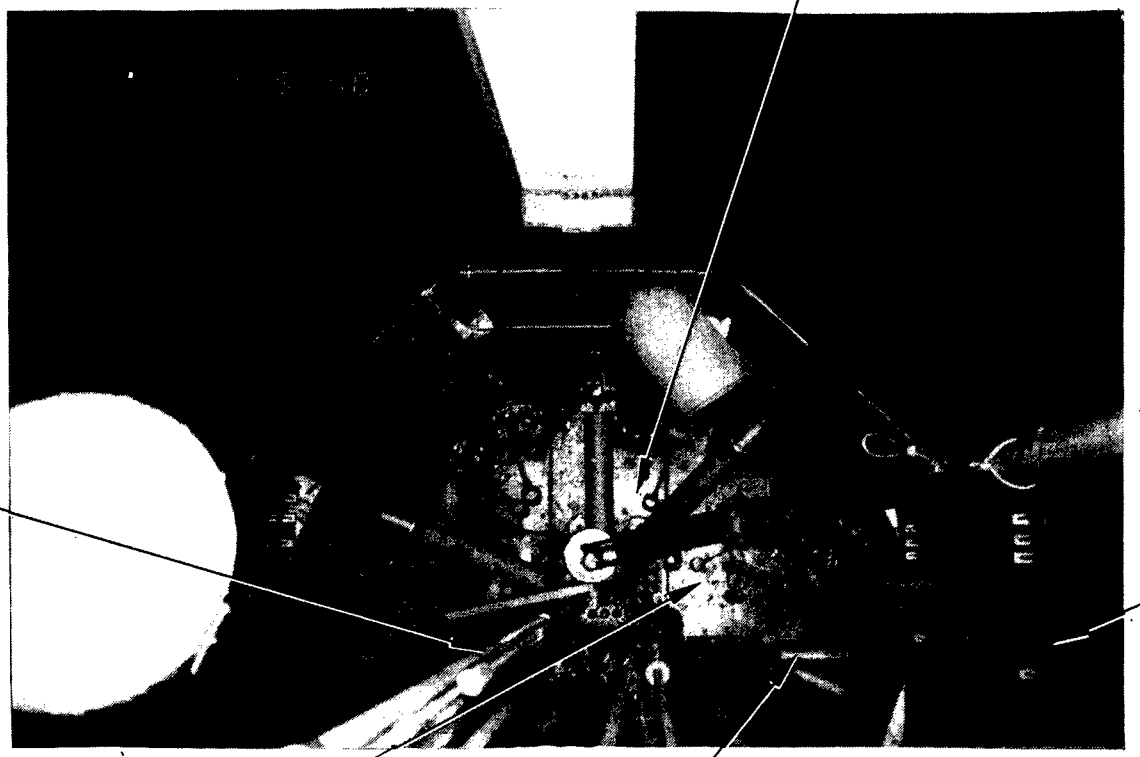


Figure 20. Smear survey results for internal components of reactor vessel (View No. 2).

Table 2. Summary of the results of the AMTL Building 100 smear sampling

Location	Beta-Gamma (dpm/100 cm^2)	Alpha (dpm/100 cm^2)
Basement		
Inside Tubes of the Storage Facility	293	<20
All Other Basement Smears	<200	<20
Main Floor		
All Main-Floor Smears	<200	<20
First Platform		
All First-Platform Smears	<200	<20
Second Platform		
All Second-Platform Smears	<200	<20
Reactor Vessel Internals		
Floor by the Access Ladder	204	<20
All Other Reactor-Vessel Internal Smears	<200	<20
Reactor Annulus		
Stainless-Steel Racks	293-395	<20
Annulus Floor	200-725	<20
Stainless-Steel Piping below Reactor Gate	749-5707	<20

Table 3. Summary of the results of the AMTL Building 100 radiation survey

Location	Contact-Radiation Reading (mR/h)
Basement	
Demineralizer	2.0-6.0
Heat Exchangers	0.3
Fission-Product Monitor	0.05
Main Floor	
Californium-252 Source	16.0
Mobile N-Ray	0.2
First Platform	
Reactor Keeper Slide	0.2
Second Platform	
Reactor Top	0.7
Magnets in Cabinet	0.4
Reactor Vessel Internals	
Blind Flanges	50.0-550.0
Slant Tubes	8.0-30.0
Valves	10.0-60.0
Pedestal (top)	550.0
Pedestal (bottom)	15.0
Reactor Annulus	
Stainless-Steel Racks and Stainless-Steel Pipe	55.0
Below Reactor Gate	1,300.0
General Body Field by Stainless-Steel Pipe at 3 ft	18.0

4.3 Cistern 242, Waste Water Retention Tank

Cistern 242 was filled with water during the radiological surveys conducted at AMTL during September 1989 and was not surveyed at that time. Smears and sediment samples were also postponed until the tank is pumped. The water in the cistern was sampled during February 1990 and found to be well below the radioactivity levels of drinking-water standards. There was no measurable gamma activity, other than the natural potassium-40 and radon/thoron daughters from the natural uranium and thorium decay chains. The gross alpha and beta activity levels for the sample in μCi/mL were $(2 \pm 5) \times 10^{-10}$ and $(1.3 \pm 0.17) \times 10^{-8}$, respectively.[10]

Samples were not collected from the interior of Cistern 242 during the week of March 26, 1990, as the water had not been removed when the EG&G Idaho sample team was at AMTL. Based on the above results of the analysis of the water sample taken in February 1990 and on the low levels of contamination found in the reactor vessel, it is assumed that the cistern does not contain any substantial amount of radioactively contaminated materials in the form of sediment or sludge. If the cistern interior is not sampled until the time of the decommissioning activities and is found to contain mixed waste, it could have a significant impact on the decommissioning costs.

4.4 Area Surrounding Building 100 and Cistern 242

During September 1989, five outside soil grab samples were collected around the reactor containment structure. One soil sample was also collected between Building 97 and Cistern 242 because hand-held gamma instrumentation detected higher-than-background levels of radionuclides. These soil samples were obtained only to be used as gross indicators to ascertain whether or not contamination had migrated outside the reactor containment facility. As the samples were not obtained using proper sampling protocol and are not legally defensible, the results are not reported in this report.

In March 1990, sediment and soil samples were collected at the surface and subsurface from locations around Building 100 and Cistern 242 using proper sampling protocol[11] (see Figure 21). These biased and random samples were collected to determine the variance of possible contaminants on the surface and at depths surrounding these areas. The cistern and reactor area samples were analyzed by the following Environmental Protection Agency (EPA) methods as specified in the Sampling and Analysis Plan for the MTL Cistern and Reactor Area[11]: metals by inductively coupled plasma (ICP) atomic emission spectroscopy (SW-846, method 6010), lead by graphite furnace atomic absorption spectroscopy (GFAAS, method 7421), and mercury by atomic absorption (AA, method 7471/7470).

In addition to the above analyses, a broad suite of analyses for organic compounds was also performed at two sample locations (MTL0901MP and MTL0902MP). These analyses were conducted to the following EPA methods: volatile organics by method 8240, semivolatile organics by method 8270, polychlorinated biphenyls (PCBs)/pesticides by method 8080, organophosphorus pesticides by method 8140, and chlorinated herbicides by method 8150 (see Appendix A[a]).

Table 4 provides the results of the chemical analyses for the above sediment and soil samples collected around Building 100 and Cistern 242.

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a. The main purpose of including chemical analyses of soil samples collected around Building 100 and Cistern 242 during this characterization effort was to identify any potential hazard to workers during decommissioning. Release of the site by the NRC for unrestricted use depends only on radioisotopic concentrations in the soil.

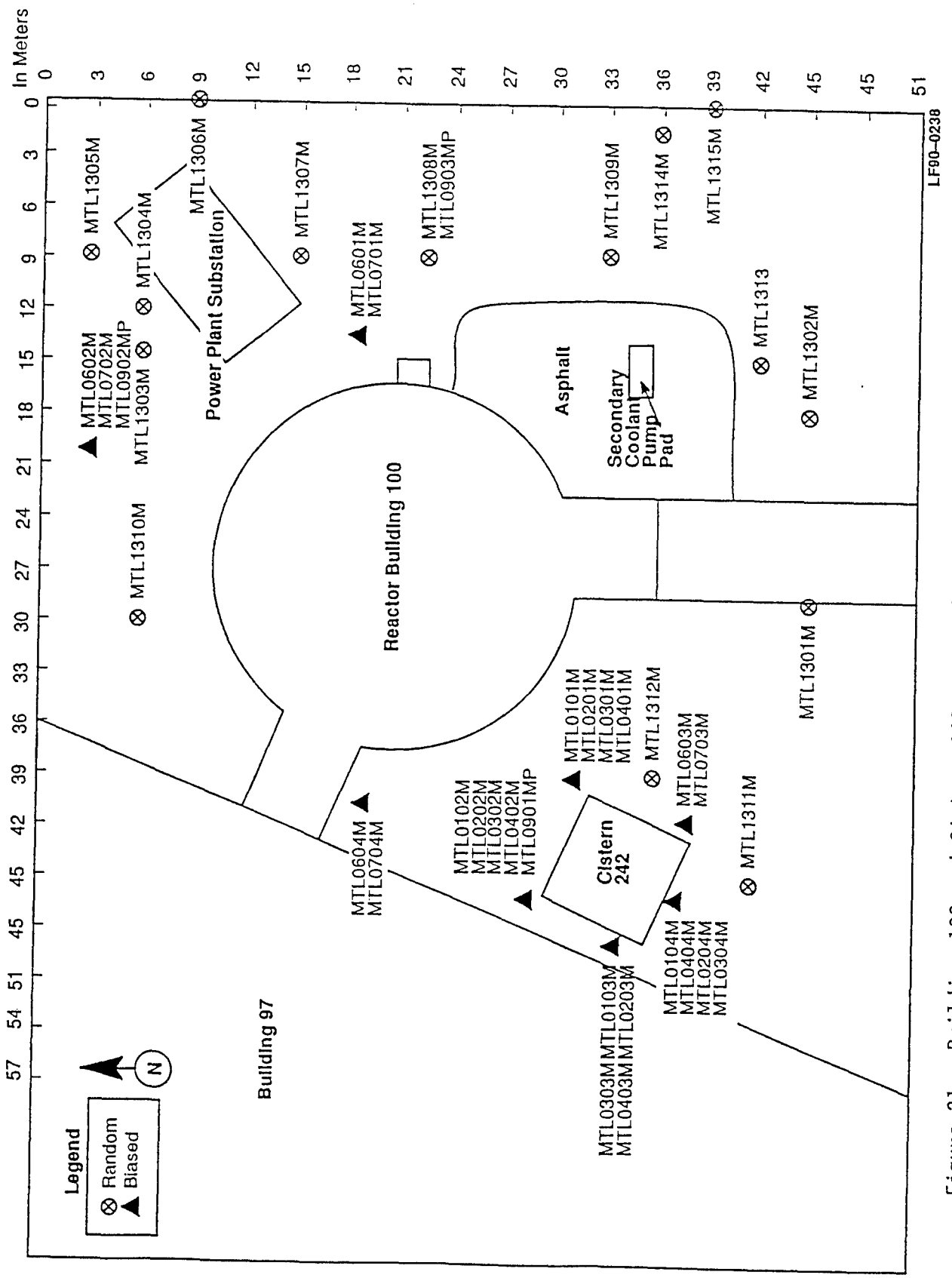

Figure 21. Building 100 and Cistern 242 area sediment and soil sample locations.

Table 4. Summary of the results of the chemical analyses for surface and subsurface sediment and soil samples collected around Building 100 and Cistern 242

Sample No.	LOCATION	DEPTH (ft)	TYPE	Sb (mg/kg)	Ba (mg/kg)	Be (mg/kg)	Cd (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Hg (mg/kg)	Ni (mg/kg)	Se (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
U_t -				2.5	72	0.95	0.44	6.7	23	92.4	0.4	20.80	1.9	376	161
MTL0101M	CISTERN	2-3						7.18							
MTL0201M	CISTERN	5-6						7.04							
MTL0301M	CISTERN	9-10						7.07	29.3						
MTL0401M	CISTERN	15-16						7.61	24.6						
MTL0102M	CISTERN	2-3			75.3			8.60	28.3			31.1			
MTL0202M	CISTERN	5-6			80.4	0.991		9.93	26.7			23.1		397	
MTL0302M	CISTERN	9.5-10.5			80.8			8.65	29.1			23.6			
MTL0402M	CISTERN	14-16						8.23							
MTL0103M	CISTERN	2-3			91.6				26.7			26.7			204
MTL0203M	CISTERN	5-6			121		1.01		29.9			23.7			355
MTL0303M	CISTERN	9-10			78.3				24.9			25.7			
MTL0403M	CISTERN	14-15			97.2	0.957			32.9			26.8		467	
MTL0104M	CISTERN	2-3			100		1.17		24.9			22.9			576
MTL0204M	CISTERN	5-6		11	86		0.534		25.6			23.8			245
MTL0304M	CISTERN	9-10			83.6		0.552		27.3			21.3			202
MTL0404M	CISTERN	14-15													
MTL0601M	REACTOR AREA	SURFACE					0.473		26.6						
MTL0701M	REACTOR AREA				96.4			10.4	37.1			33.4			
MTL0602M	REACTOR AREA	SURFACE													
MTL0702M	REACTOR AREA				90.6			11.4	38.4			25.4			
MTL0603M	REACTOR AREA	SURFACE								96.2					
MTL0703M	REACTOR AREA														
MTL0604M	REACTOR AREA	SURFACE					0.503		27.6						163
MTL0704M	REACTOR AREA				89.1			10.2	34.2						
MTL1301M	REACTOR AREA	SURFACE													
MTL1302M	REACTOR AREA	SURFACE													
MTL1303M	REACTOR AREA	SURFACE													
MTL1304M	REACTOR AREA	SURFACE					0.477								
MTL1305M	REACTOR AREA	SURFACE													
MTL1306M	REACTOR AREA	SURFACE													
MTL1307M	REACTOR AREA	SURFACE						7.54							
MTL1308M	REACTOR AREA	SURFACE					0.482	6.82	29.7						
MTL1309M	REACTOR AREA	SURFACE													
MTL1310M	REACTOR AREA	SURFACE					0.892								
MTL1311M	REACTOR AREA	SURFACE					0.643		31.6		0.429	27.4			
MTL1312M	REACTOR AREA	SURFACE			82.7		0.459	8.62	37.2						
MTL1313M	REACTOR AREA	SURFACE													
MTL1314M	REACTOR AREA	SURFACE													
MTL1315M	REACTOR AREA	SURFACE													
MTL0404AM	CISTERN	14-16	APPDX IX		93.3	1.00		14.2	37.7			28.0		404	
MTL0704AM	REACTOR AREA	15-17	APPDX IX		112			15.3	44.5			31.7		510	
MTL0901MP	CISTERN	9-10	REPLICATE					8.22							
MTL0902MP	REACTOR AREA	15-17	REPLICATE		82.9			11.6				23.2			
MTL0903MP	REACTOR AREA	SURFACE	REPLICATE		79.2			6.92							

Blank spaces indicate concentrations within the range of background concentrations. Background concentrations and sample locations are provided in Appendix C.

Comparison to background soils may not be representative of soils at AMTL due to the number of different types of soils used for fill material at the reactor site.[b] There were no volatile organic compounds, semivolatiles, PCBs/organochlorine pesticides, organophosphorus pesticides/chlorinated herbicides, lead, or mercury detected at elevations above EPA regulatory limits pertaining to the identification and classification of hazardous wastes [as specified in 40 CFR 261, "Identification and Listing of Hazardous Waste," and including the toxicity characteristic revisions effective September 25, 1990 (Federal Register, March 29, 1990)]. Although metals were detected at concentrations greater than the upper tolerance limits with 95% confidence, all detections are less than EPA regulatory limits for hazardous wastes.[12] The EPA regulatory limits are those that pertain to the identification and classification of hazardous wastes, as specified in 40 CFR 261. Because metals were the only contaminants detected in soils, the relevant section of these regulations is that which pertains to the identification of "toxicity characteristic metals" identified in 40 CFR 261.24, through use of either the Toxicity Characteristic Leaching Procedure [(TCLP), EPA Method 1311, 40 CFR 261 Appendix II] or through a total analysis (see below). Effective September 25, 1990, the TCLP replaces the EP toxicity leaching procedure.

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b. Comparisons with background samples is an appropriate method to indicate if significant contamination has resulted from a given activity or process, and the concept can be applied to any environmental setting, including industrial and residential setting. As indicated above, the use of different types of soil for fill materials at the reactor site may complicate these comparisons. However, the soil-sampling data at these areas show that gross chemical contamination (from spills, for example) has not occurred, and that hazardous waste/mixed waste would not be generated by any decommissioning activities involving soil removal or disturbance.

The TCLP method states that the TCLP test need not be run where a total analysis of the waste indicates that the regulatory thresholds could not possibly be exceeded. This situation is applicable to the soil samples taken from around Building 100 and Cistern 242, where total analyses for metals (using SW 846 methods) showed levels that could not possibly exceed the regulatory limits if subjected to the TLCP. In this and other cases where solid samples are involved, maximum TCLP levels are calculated by assuming a dilution factor of 20 times the total metal concentration (based on 100 g of sample and a dilution with 2 L of extraction fluid), and a theoretical worst-case leaching of 100%:

$$\text{maximum TCLP concentration (mg/L)} = \frac{\text{total contaminant conc. (mg/kg)} \times 0.1 \text{ kg}}{2.0 \text{ L}}$$

Under this worst-case assumption, metal concentrations in all samples are below the EPA toxicity characteristic limits in 40 CFR 261.24. (These limits are shown in Appendix B of this characterization report).

The March sediment and soil samples were also analyzed for gamma-emitting nuclides by gamma spectroscopy. In Table 5 are summarized the gamma-analysis results that were positive but that did not satisfy standard EG&G Radiation Measurements Laboratory (RML) selection criteria and those of the analyst. Rejection criteria codes are described below Table 5.[13]

Table 6 summarizes the man-made radionuclide results from the computer-generated gamma-ray analysis summary that were found to be true positive according to the criteria contained in the EG&G RML procedure, "DM-1: Evaluation and Verification of Data for Radionuclide Identification and Selection."[13] True positive results are defined as values that have a measured activity >2 measured standard deviations.

Table 6 includes the activity with the associated statistical uncertainty, Activity (S), and the activity with total uncertainty, Activity (T).

Table 5. Analyst's results of rejected gamma-emitting nuclides for March 1990 sediment and soil samples

Sample ID No.	Radionuclide (Gamma)	Analyst's Rejection Code
MTL0101AG	Cs-137	1, 2
MTL0102AG	Cs-137	1, 2
	Eu-155	1, 2, 3, 4
MTL0202AG	Cs-137	1, 2
MTL0203AG	Cs-137	1, 2
	Eu-154	1, 4
MTL0302AG	Zn-65	1, 2, 4
MTL0303AG	Co-60	1, 2
MTL0404AG	Eu-155	1, 2, 3
MTL0601AG	Agm-110	1, 2, 4
MTL0602AG	Eu-155	1, 2, 3, 4
MTL0702AG	Eu-152	1, 2, 4
MTL0703AG	Eu-155	1, 2, 3, 4
MTL0801G	Cs-134	1, 2
MTL0805G	Agm-110	1, 2, 4
MTL1303G	Eu-155	1, 2, 3, 4
MTL1307G	Cs-134	1, 2
	Cs-137	1, 2
	Eu-155	1, 2, 3, 4
MTL1309G	Cs-137	1, 2
MTL1313G	Eu-155	1, 2, 3, 4
MTL1315G	Eu-152	1, 2, 4

Rejection Criteria Codes:

1. Uncertainty too high to be accepted by analyst.
2. Radionuclide result below quoted RML detection limits.
3. Other radionuclide gamma-ray interferences.
4. Graphical display of analyzed photopeaks (VTP) showed unacceptable photopeak fitting results.

Table 6. Analyst's results of man-made true positive gamma-emitting nuclides for March 1990 sediment and soil samples

Sample ID No.	Radionuclide (Gamma)	Activity (S)[1] (pCi/g)	Uncertainties (%) Statistical	Geo	Eff	Activity (T)[2] (pCi/g)
MTL0103AG	Co-60	(+6.32 +/- .30)E-01	4.8	5.0	5.0	(+6.32 +/- .54)E-01
	Cs-137	(+1.89 +/- .22)E-01	11.5	5.0	5.0	(+1.89 +/- .26)E-01
MTL0104AG	Cs-137	(+3.18 +/- .34)E-01	10.6	5.0	5.0	(+3.18 +/- .40)E-01
MTL0203AG	Co-60	(+2.45 +/- .29)E-01	11.6	5.0	5.0	(+2.45 +/- .33)E-01
MTL0204AG	Cs-137	(+1.62 +/- .19)E-01	11.8	5.0	5.0	(+1.62 +/- .22)E-01
MTL0304AG	Cs-137	(+1.72 +/- .28)E-01	16.2	5.0	5.0	(+1.72 +/- .30)E-01
MTL0601AG	Cs-137	(+2.12 +/- .31)E-01	14.6	5.0	5.0	(+2.12 +/- .34)E-01
MTL0602AG	Cs-137	(+1.83 +/- .31)E-01	16.8	5.0	5.0	(+1.83 +/- .33)E-01
MTL0603AG	Cs-137	(+4.89 +/- .42)E-01	8.5	5.0	5.0	(+4.89 +/- .54)E-01
MTL0604AG	Cs-137	(+2.83 +/- .34)E-01	12.0	5.0	5.0	(+2.83 +/- .40)E-01
MTL0801G	Cs-137	(+2.50 +/- .34)E-01	13.5	5.0	5.0	(+2.50 +/- .38)E-01
MTL0802G	Cs-137	(+3.79 +/- .46)E-01	12.0	5.0	5.0	(+3.79 +/- .53)E-01
MTL0803G	Cs-137	(+4.07 +/- .60)E-01	14.6	5.0	5.0	(+4.07 +/- .66)E-01
MTL0804G	Cs-137	(+1.91 +/- .41)E-01	21.5	5.0	5.0	(+1.91 +/- .43)E-01
MTL0805G	Cs-137	(+3.24 +/- .42)E-01	13.0	5.0	5.0	(+3.24 +/- .48)E-01
MTL0903GP	Cs-137	(+1.81 +/- .28)E-01	15.4	5.0	5.0	(+1.81 +/- .31)E-01
MTL1301G	Cs-137	(+1.21 +/- .37)E-01	30.8	5.0	5.0	(+1.21 +/- .38)E-01
MTL1302G	Cs-137	(+1.26 +/- .30)E-01	23.8	5.0	5.0	(+1.26 +/- .31)E-01
MTL1303G	Cs-137	(+2.63 +/- .40)E-01	15.1	5.0	5.0	(+2.63 +/- .44)E-01

Table 6. Analyst's results of man-made true positive gamma-emitting nuclides for March 1990 sediment and soil samples (cont.)

Sample ID No.	Radionuclide (Gamma)	Activity (S)[1] (pCi/g)	Uncertainties (%) Statistical	Geo	Eff	Activity (T)[2] (pCi/g)
MTL1304G	Cs-137	(+4.89 +/- .53)E-01	10.8	5.0	5.0	(+4.89 +/- .63)E-01
MTL1305G	Cs-137	(+2.07 +/- .30)E-01	14.6	5.0	5.0	(+2.07 +/- .34)E-01
MTL1306G	Cs-137	(+2.19 +/- .29)E-01	13.2	5.0	5.0	(+2.19 +/- .33)E-01
MTL1308G	Cs-137	(+2.41 +/- .33)E-01	13.5	5.0	5.0	(+2.41 +/- .37)E-01
MTL1310G	Cs-137	(+4.83 +/- .39)E-01	8.0	5.0	5.0	(+4.83 +/- .52)E-01
MTL1311G	Cs-137	(+4.12 +/- .39)E-01	9.4	5.0	5.0	(+4.12 +/- .49)E-01
MTL1312G	Cs-137	(+3.64 +/- .38)E-01	10.5	5.0	5.0	(+3.64 +/- .46)E-01
MTL1313G	Cs-137	(+2.10 +/- .32)E-01	15.3	5.0	5.0	(+2.10 +/- .35)E-01
MTL1314G	Cs-137	(+2.03 +/- .27)E-01	13.4	5.0	5.0	(+2.03 +/- .31)E-01
MTL1315G	Cs-137	(+1.17 +/- .39)E-01	33.1	5.0	5.0	(+1.17 +/- .40)E-01

Note: (1) ACTIVITY (S) Includes the statistical uncertainty, from counting statistics and photopeak fitting--expressed as 1 standard deviation.

(2) ACTIVITY (T) Includes the total uncertainty resulting from the statistical, sample/detector geometry, and efficiency. These uncertainties have been propogated in quadrature--expressed as 1 standard deviation.

The statistical uncertainty includes the statistics associated with counting, backgrounds, and photopeak fitting. The total uncertainty includes the statistical uncertainty, the estimates of the uncertainty in the sample geometry (5%), and the detector efficiency (5%). These uncertainties have been propagated in quadrature and are expressed as one estimated standard deviation. It is recommended that the activity results with total uncertainties, Activity (T), be used for quantitative purposes on Table 6.

Gamma-emitting nuclides were detected in soil samples collected in March 1990, and the concentrations are summarized in Table 6. The values contained in Table 6 were reported after background values were subtracted. The two samples containing positive indications of Co-60 (MTL0103AG and MTL0203AG) were taken from the area between Building 97 and Cistern 242, where elevated radiation readings were detected during the preliminary radiological surveys performed in September 1989.

The NRC has no published release criteria for radioisotopes in soil. The NRC determines whether or not a site can be released based on an NRC site-specific assessment. For comparison, the Department of Energy (DOE) has published release criteria for INEL soils[14] that have radioisotopic concentrations in releasable soil that are orders of magnitude higher than the AMTL samples. Since the DOE criteria are based on very extensive pathways analysis studies, it would appear that the AMTL soil levels have a very high probability of meeting NRC requirements.

During the analysis of soil samples for alpha-emitters, sample number MTL 0102 was the only sample that contained statistically positive Am-241 and/or Pu-238. The activity concentration of this sample is 0.21 pCi/g. As stated previously, the NRC has no published release criteria for soil. For comparison, however, the DOE INEL soil release criteria allow soil to be released with a Pu-238 concentration of 300 pCi/g and an Am-241 concentration of 80 pCi/g. It would appear that the AMTL soil has a very high probability of meeting NRC requirements because the AMTL alpha-emitting radioisotopic concentration is orders of magnitude lower than the DOE criteria, which are base on very extensive pathways analysis studies.[14]

5. POTENTIAL PROBLEM AREAS

No major problems are anticipated during the decommissioning of the AMTL reactor. This viewpoint is based on the results of the limited characterization described in this report and on the operating history of the reactor. However, during decommissioning of the AMTL reactor (or any other nuclear facility), there is the possibility that previously undetected, sequestered contamination will be encountered. The potential for discovering unanticipated contamination exists in any of the reactor systems, components, and equipment, but the impact of any surprises can be minimized through standard decommissioning practices, which include continuous radiological monitoring as work proceeds.

The AMTL reactor system that presents the greatest potential for having sequestered, unexpected contamination is probably the radioactive liquid-waste system, especially Cistern 242 since the cistern has not been characterized except for radiological analysis of the water, which showed no contamination. Discovery of radioactive or hazardous contamination in the cistern or soil beneath the cistern during decommissioning could increase the project cost and delay the schedule.

In addition to the liquid-waste system, another potential problem is the possible unexpected, sequestered contamination in concrete. This could especially be a problem if partial dismantlement is the selected decommissioning alternative and the sequestered contamination is discovered in the concrete floors and other concrete to be left intact in the reactor building.

6. REFERENCES

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13. K. J. Durfee et al., RML Gamma-Ray Analyses of MTL Cistern and Reactor Area Samples for Environmental Restoration Programs, ST-CS-023-90, June 1990.

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APPENDIX A

EPA APPENDIX IX ANALYTES

APPENDIX A

EPA APPENDIX IX ANALYTES

(Ref. 40 CFR 264)[a,b]

APPENDIX IX – GROUND-WATER MONITORING LIST[1]

Common name[2]	CAS RN[3]	Chemical abstracts service index name[4]	Suggested methods[5]	PQL (µg/L)[6]
Acenaphthene	83-32-9	Acenaphthylene, 1,2-dihydro-	8100	200
			8270	10
Acenaphthylene	208-96-8	Acenaphthylene	8100	200
			8270	10
Acetone	67-64-1	2-Propanone	8240	100
Acetophenone	98-86-2	Ethanone, 1-phenyl-	8270	10
Acetonitrile; Methyl cyanide	75-05-8	Acetonitrile	8015	100
2-Acetylaminofluorene; 2-AAF	53-96-3	Acetamide, N-9H-fluoren-2-yl-	8270	10
Acrolein	107-02-8	2-Propenal	8030	5
			8240	5
Acrylonitrile	107-13-1	2-Propenenitrile	8030	5
			8240	5
Aldrin	309-00-2	1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro- (1α,4α,4aβ,5α,8α,8aβ)-	8080	0.05
			8270	10
Allyl chloride	107-05-1	1-Propene, 3-chloro-	8010	5
			8240	100
4-Aminobiphenyl	92-67-1	[1,1'-Biphenyl]-4-amine	8270	10
Aniline	62-53-3	Benzenamine	8270	10
Anthracene	120-12-7	Anthracene	8100	200
			8270	10
Antimony	(Total)	Antimony	6010	300
			7040	2,000
			7041	30
Aramite	140-57-8	Sulfurous acid, 2-chloroethyl 2-[4-(1,1-dimethylethyl)phenoxy]-1-methylethyl ester	8270	10
Arsenic	(Total)	Arsenic	6010	500
			7060	10
			7061	20
Barium	(Total)	Barium	6010	20
			7080	1,000
Benzene	71-43-2	Benzene	8020	2
			8240	5

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a. Metals analyses were conducted at sample locations shown on Figure 21. Organic analyses were conducted for samples taken at two locations: MTL0901MP and MTL0902MP. See text on page 39.

b. Specific analytical methods are identified in the Sampling and Analysis Plan for the MTL Cistern and Reactor Area.[11]

Common name [2]	CAS RN [3]	Chemical abstracts service index name [4]	Suggested methods [5]	PQL (µg/L) [6]
Benzo[a]anthracene; Benzanthracene	56-55-3	Benz[a]anthracene	8100	200
			8270	10
Benzo[b]fluoranthene	205-99-2	Benz[e]acephenanthrylene	8100	200
			8270	10
Benzo[k]fluoranthene	207-08-9	Benzo[k]fluoranthene	8100	200
			8270	10
Benzo[ghi]perylene	191-24-2	Benzo[ghi]perylene	8100	200
			8270	10
Benzo[a]pyrene	50-32-8	Benzo[a]pyrene	8100	200
			8270	10
Benzyl alcohol	100-51-6	Benzenemethanol	8270	20
Beryllium	(Total)	Beryllium	6010	3
			7090	50
			7091	2
alpha-BHC	319-84-6	Cyclohexane, 1,2,3,4,5,6-hexachloro-,(1α,2α,3β,4α,5β,6β)-	8080	0.05
			8250	10
beta-BHC	319-85-7	Cyclohexane, 1,2,3,4,5,6-hexachloro-,(1α,2β,3α,4β,5α,6β)-	8080	0.05
			8250	40
delta-BHC	319-86-8	Cyclohexane, 1,2,3,4,5,6-hexachloro-,(1α,2α 3α,4β,5α,6β)-	8080	0.1
			8250	30
gamma-BHC; Lindane	58-89-9	Cyclohexane, 1,2,3,4,5,6-hexachloro-,(1α,2α,3β,4α,5α,6β)-	8080	0.05
			8250	10
Bis(2-chloroethoxy)methane	111-91-1	Ethane, 1,1'-[methylenebis (oxy)]bis[2-chloro-	8270	10
Bis(2-chloroethyl)ether	111-44-4	Ethane, 1,1'-oxybis[2-chloro-	8270	10
Bis(2-chloro-1-methylethyl) ether; 2,2'-Dichlorodiisopropyl ether	108-60-1	Propane, 2,2'-oxybis[1-chloro-	8010	100
			8270	10
Bis(2-ethylhexyl) phthalate	117-81-7	1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl)ester	8060	20
			8270	10
Bromodichloromethane	75-27-4	Methane, bromodichloro-	8010	1
			8240	5
Bromoform; Tribromomethane	75-25-2	Methane, tribromo-	8010	2
			8240	5
4-Bromophenyl phenyl ether	101-55-3	Benzene, 1-bromo-4-phenoxy-	8270	10
Butyl benzyl phthalate; Benzyl butyl phthalate	85-68-7	1,2-Benzenedicarboxylic acid, butyl phenylmethyl ester	8060	5
			8270	10
Cadmium	(Total)	Cadmium	6010	40
			7130	50
			7131	1
Carbon disulfide	75-15-0	Carbon disulfide	8240	5
Carbon tetrachloride	56-23-5	Methane, tetrachloro-	8010	1
			8240	5
Chlordane	57-74-9	4,7-Methano-1H-indene, 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-	8080	0.1
			8250	10
p-Chloroaniline	106-47-8	Benzenamine, 4-chloro-	8270	20
Chlorobenzene	108-90-7	Benzene, chloro-	8010	2
			8020	2
			8240	5
Chlorobenzilate	510-15-6	Benzeneacetic acid, 4-chloro-α-(4-chlorophenyl)-α-hydroxy-ethyl ester	8270	10
p-Chloro-m-cresol	59-50-7	Phenol, 4-chloro-3-methyl-	8040	5
			8270	20
Chloroethane; Ethyl chloride	75-00-3	Ethane, chloro-	8010	5
			8240	10
Chloroform	67-66-3	Methane, trichloro-	8010	0.5
			8240	5
2-Chloronaphthalene	91-58-7	Naphthalene, 2-chloro-	8120	10
			8270	10
2-Chlorophenol	95-57-8	Phenol, 2-chloro-	8040	5
			8270	10

Common name [2]	CAS RN [3]	Chemical abstracts service index name [4]	Suggested methods [5]	PQL (µg/L) [6]
4-Chlorophenyl phenyl ether	7005-72-3	Benzene, 1-chloro-4-phenoxy-	8270	10
Chloroprene	126-99-8	1,3-Butadiene, 2-chloro-	8010	50
			8240	5
Chromium	(Total)	Chromium	6010	70
			7190	500
			7191	10
Chrysene	218-01-9	Chrysene	8100	200
			8270	10
Cobalt	(Total)	Cobalt	6010	70
			7200	500
			7201	10
Copper	(Total)	Copper	6010	60
			7210	200
m-Cresol	108-39-4	Phenol, 3-methyl-	8270	10
o-Cresol	95-48-7	Phenol, 2-methyl-	8270	10
p-Cresol	106-44-5	Phenol, 4-methyl-	8270	10
Cyanide	57-12-5	Cyanide	9010	40
2,4-D; 2,4-Dichlorophenoxyacetic acid	94-75-7	Acetic acid, (2,4-dichlorophenoxy)-	8150	10
4,4'-DDD	72-54-8	Benzene 1,1'-(2,2-dichloroethylidene)bis[4-chloro-	8080	0.1
			8270	10
4,4'-DDE	72-55-9	Benzene 1,1'-(dichloroethylidene)bis[4-chloro-	8080	0.05
			8270	10
4,4'-DDT	50-29-3	Benzene 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro-	8080	0.1
			8270	10
Diallate	2303-16-4	Carbamothioic acid, bis(1-methylethyl)- , S- (2,3-dichloro-2-propenyl) ester	8270	10
Dibenz[a,h]anthracene	53-70-3	Dibenz[a,h]anthracene	8100	200
			8270	10
Dibenzofuran	132-64-9	Dibenzofuran	8270	10
Dibromochloromethane; Chlorodibromomethane	124-48-1	Methane, dibromochloro-	8010	1
			8240	5
1,2-Dibromo-3-chloropropane; DBCP	96-12-8	Propane, 1,2-dibromo-3-chloro-	8010	100
			8240	5
			8270	10
1,2-Dibromoethane; Ethylene dibromide	106-93-4	Ethane, 1,2-dibromo-	8010	10
			8240	5
Di-n-butyl phthalate	84-74-2	1,2-Benzenedicarboxylic acid, dibutyl ester	8060	5
			8270	10
o-Dichlorobenzene	95-50-1	Benzene, 1,2-dichloro-	8010	2
			8020	5
			8120	10
			8270	10
m-Dichlorobenzene	541-73-1	Benzene, 1,3-dichloro-	8010	5
			8020	5
			8120	10
			8270	10
p-Dichlorobenzene	106-46-7	Benzene, 1,4-dichloro-	8010	2
			8020	5
			8120	15
			8270	10
3,3'-Dichlorobenzidine	91-94-1	[1,1'-Biphenyl]-4,4'-diamine, 3,3'-dichloro-	8270	20
trans-1,4-Dichloro-2-butene	110-57-6	2-Butene, 1,4-dichloro-, (E)-	8240	5
Dichlorodifluoromethane	75-71-8	Methane, dichlorodifluoro-	8010	10
			8240	5
1,1-Dichloroethane	75-34-3	Ethane, 1,1-dichloro-	8010	1
			8240	5
1,2-Dichloroethane; Ethylene dichloride	107-06-2	Ethane, 1,2-dichloro-	8010	0.5
			8240	5

Common name [2]	CAS RN [3]	Chemical abstracts service index name [4]	Suggested methods [5]	PQL (µg/L) [6]
1,1-Dichloroethylene; Vinylidene chloride	75-35-4	Ethene, 1,1-dichloro-	8010	1
			8240	5
trans-1,2-Dichloroethylene	156-60-5	Ethene, 1,2-dichloro-, (E)-	8010	1
			8240	5
2,4-Dichlorophenol	120-83-2	Phenol, 2,4-dichloro-	8040	5
			8270	10
2,6-Dichlorophenol	87-65-0	Phenol, 2,6-dichloro-	8270	10
1,2-Dichloropropane	78-87-5	Propane, 1,2-dichloro-	8010	0.5
			8240	5
cis-1,3-Dichloropropene	10061-01-5	1-Propene, 1,3-dichloro-, (Z)-	8010	20
			8240	5
trans-1,3-Dichloropropene	10061-02-6	1-Propene, 1,3-dichloro-, (E)-	8010	5
			8240	5
Dieldrin	60-57-1	2,7:3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-, (1aα,2β,2aα,3β,6β,6aα,7β,7aα)-	8080	0.05
			8270	10
Diethyl phthalate	84-66-2	1,2-Benzenedicarboxylic acid, diethyl ester	8060	5
			8270	10
O,O-Diethyl O-2-pyrazinyl phosphorothioate; Thionazin	297-97-2	Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester	8270	10
Dimethoate	60-51-5	Phosphorodithioic acid, O,O-dimethyl S-[2-(methylamino)-2-oxoethyl] ester	8270	10
p-(Dimethylamino)azobenzene	60-11-7	Benzenamine, N,N-dimethyl-4-(phenylazo)-	8270	10
7,12-Dimethylbenz[a]anthracene	57-97-6	Benz[a]anthracene, 7,12-dimethyl-	8270	10
3,3'-Dimethylbenzidine	119-93-7	[1,1'-Biphenyl]-4,4'-diamine, 3,3'-dimethyl-	8270	10
alpha, alpha-Dimethylphenethylamine	122-09-8	Benzeneethanamine, α,α-dimethyl-	8270	10
2,4-Dimethylphenol	105-67-9	Phenol, 2,4-dimethyl-	8040	5
			8270	10
Dimethyl phthalate	131-11-3	1,2-Benzenedicarboxylic acid, dimethyl ester	8060	5
			8270	10
m-Dinitrobenzene	99-65-0	Benzene, 1,3-dinitro-	8270	10
4,6-Dinitro-o-cresol	534-52-1	Phenol, 2-methyl-4,6-dinitro-	8040	150
			8270	50
2,4-Dinitrophenol	51-28-5	Phenol, 2,4-dinitro-	8040	150
			8270	50
2,4-Dinitrotoluene	121-14-2	Benzene, 1-methyl-2,4-dinitro-	8090	0.2
			8270	10
2,6-Dinitrotoluene	606-20-2	Benzene, 2-methyl-1,3-dinitro-	8090	0.1
			8270	10
Dinoseb; DNBP; 2-sec-Butyl-4,6-dinitrophenol	88-85-7	Phenol, 2-(1-methylpropyl)-4,6-dinitro-	8150	1
			8270	10
Di-n-octyl phthalate	117-84-0	1,2-Benzenedicarboxylic acid, dioctyl ester	8060	30
			8270	10
1,4-Dioxane	123-91-1	1,4-Dioxane	8015	150
Diphenylamine	122-39-4	Benzenamine, N-phenyl-	8270	10
Disulfoton	298-04-4	Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio)- S-[2-ethyl]ester	8140	2
			8270	10
Endosulfan I	959-98-8	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-, 3-oxide, (3α,5aβ,6α,9α,9aβ)-	8080	0.1
			8250	10
Endosulfan II	33213-65-9	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro- 1,5,5a,6,9,9a-hexahydro-, 3-oxide, (3α,5aα,6β,9β,9aα)-	8080	0.05
Endosulfan sulfate	1031-07-8	6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro- 1,5,5a,6,9,9a-hexahydro-, 3,3-dioxide.	8080	0.5
			8270	10
Endrin	72-20-8	2,7:3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-, (1aα, 2β,2aβ,3α,6α, 6aβ,7β,7aα)-	8080	0.1
			8250	10
Endrin aldehyde	7421-93-4	1,2,4-Methenocyclopenta[cd]pentalene-5-carboxaldehyde, 2,2a,3,3,4,7-hexachlorodecahydro-, (1α,2β,2aβ,4β,4aβ,5β,6aβ,6bβ,7R*)-	8080	0.2
			8270	10

Common name [2]	CAS RN [3]	Chemical abstracts service index name [4]	Suggested methods [5]	PQL (µg/L) [6]
Ethylbenzene	100-41-4	Benzene, ethyl-	8020	2
			8240	5
Ethyl methacrylate	97-63-2	2-Propenoic acid, 2-methyl-, ethyl ester	8015	10
			8240	5
			8270	10
Ethyl methanesulfonate	62-50-0	Methanesulfonic acid, ethyl ester	8270	10
Famphur	52-85-7	Phosphorothioic acid, O-[4-[(dimethylamino)sulfonyl]phenyl]-O,O-dimethyl ester	8270	10
Fluoranthene	206-44-0	Fluoranthene	8100	200
			8270	10
Fluorene	86-73-7	9H-Fluorene	8100	200
			8270	10
Heptachlor	76-44-8	4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-	8080	0.05
			8270	10
Heptachlor epoxide	1024-57-3	2,5-Methano-2H-indeno[1,2-b]oxirene, 2,3,4,5,6,7,7-heptachloro-1a,1b,5,5a,6,6a,-hexahydro-, (1aα,1bβ,2α,5α,5aβ,6β,6aα)	8080	1
			8270	10
Hexachlorobenzene	118-74-1	Benzene, hexachloro-	8120	0.5
			8270	10
Hexachlorobutadiene	87-68-3	1,3-Butadiene, 1,1,2,3,4,4-hexachloro-	8120	5
			8270	10
Hexachlorocyclopentadiene	77-47-4	1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-	8120	5
			8270	10
Hexachloroethane	67-72-1	Ethane, hexachloro-	8120	0.5
			8270	10
Hexachlorophene	70-30-4	Phenol, 2,2'-methylenebis[3,4,6-trichloro-	8270	10
Hexachloropropene	1888-71-7	1-Propene, 1,1,2,3,3,3-hexachloro-	8270	10
2-Hexanone	591-78-6	2-Hexanone	8240	50
Indeno(1,2,3-cd)pyrene	193-39-5	Indeno[1,2,3-cd]pyrene	8100	200
			8270	10
Isobutyl alcohol	78-83-1	1-Propanol, 2-methyl-	8015	50
Isodrin	465-73-6	1,4,5,8-Dimethanonaphthalene,1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a hexahydro-(1α,4α,4aβ,5β,8β,8aβ)-	8270	10
Isophorone	78-59-1	2-Cyclohexen-1-one, 3,5,5-trimethyl-	8090	60
			8270	10
Isosafrole	120-58-1	1,3-Benzodioxole, 5-(1-propenyl)-	8270	10
Kepone	143-50-0	1,3,4-Metheno-2H-cyclobuta[cd]pentalen-2-one, 1,1a,3,3a,4,5,5,5a,5b,6-decachlorooctahydro-	8270	10
Lead	(Total)	Lead	6010	40
			7420	1,000
			7421	10
Mercury	(Total)	Mercury	7470	2
Methacrylonitrile	126-98-7	2-Propenenitrile, 2-methyl-	8015	5
			8240	5
Methapyrilene	91-80-5	1,2,Ethanediamine, N,N-dimethyl-N'-2-pyridinyl-N'-(2-thienylmethyl)-	8270	10
Methoxychlor	72-43-5	Benzene, 1,1'-(2,2,2,trichloroethylidene)bis[4-methoxy-	8080	2
			8270	10
Methyl bromide; Bromomethane	74-83-9	Methane, bromo-	8010	20
			8240	10
Methyl chloride; Chloromethane	74-87-3	Methane, chloro-	8010	1
			8240	10
3-Methylcholanthrene	56-49-5	Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-	8270	10
Methylene bromide; Dibromomethane	74-95-3	Methane, dibromo-	8010	15
			8240	5
Methylene chloride; Dichloromethane	75-09-2	Methane, dichloro-	8010	5
			8240	5

Common name [2]	CAS RN [3]	Chemical abstracts service index name [4]	Suggested methods [5]	PQL (µg/L) [6]
Methyl ethyl ketone; MEK	78-93-3	2-Butanone	8015	10
			8240	100
Methyl iodide; Iodomethane	74-88-4	Methane, iodo-	8010	40
			8240	5
Methyl methacrylate	80-62-6	2-Propenoic acid, 2-methyl-, methyl ester	8015	2
			8240	5
Methyl methanesulfonate	66-27-3	Methanesulfonic acid, methyl ester	8270	10
2-Methylnaphthalene	91-57-6	Naphthalene, 2-methyl-	8270	10
Methyl parathion; Parathion methyl	298-00-0	Phosphorothioic acid, O,O-dimethyl O-(4-nitrophenyl) ester	8140	0.5
			8270	10
4-Methyl-2-pentanone; Methyl isobutyl ketone	108-10-1	2-Pentanone, 4-methyl-	8015	5
			8240	50
Naphthalene	91-20-3	Naphthalene	8100	200
			8270	10
1,4-Naphthoquinone	130-15-4	1,4-Naphthalenedione	8270	10
1-Naphthylamine	134-32-7	1-Naphthalenamine	8270	10
2-Naphthylamine	91-59-8	2-Naphthalenamine	8270	10
Nickel	(Total)	Nickel	6010	50
			7520	400
o-Nitroaniline	88-74-4	Benzenamine, 2-nitro-	8270	50
m-Nitroaniline	99-09-2	Benzenamine, 3-nitro-	8270	50
p-Nitroaniline	100-01-6	Benzenamine, 4-nitro-	8270	50
Nitrobenzene	98-95-3	Benzene, nitro-	8090	40
			8270	10
o-Nitrophenol	88-75-5	Phenol, 2-nitro-	8040	5
			8270	10
p-Nitrophenol	100-02-7	Phenol, 4-nitro-	8040	10
			8270	50
4-Nitroquinoline 1-oxide	56-57-5	Quinoline, 4-nitro-, 1-oxide	8270	10
N-Nitrosodi-n-butylamine	924-16-3	1-Butanamine, N-butyl-N-nitroso-	8270	10
N-Nitrosodiethylamine	55-18-5	Ethanamine, N-ethyl-N-nitroso-	8270	10
N-Nitrosodimethylamine	62-75-9	Methanamine, N-methyl-N-nitroso-	8270	10
N-Nitrosodiphenylamine	86-30-6	Benzenamine, N-nitroso-N-phenyl-	8270	10
N-Nitrosodipropylamine; Di-n-propylnitrosamine	621-64-7	1-Propanamine, N-nitroso-N-propyl-	8270	10
N-Nitrosomethylethylamine	10595-95-6	Ethanamine, N-methyl-N-nitroso-	8270	10
N-Nitrosomorpholine	59-89-2	Morpholine, 4-nitroso-	8270	10
N-Nitrosopiperidine	100-75-4	Piperidine, 1-nitroso-	8270	10
N-Nitrosopyrrolidine	930-55-2	Pyrrolidine, 1-nitroso-	8270	10
5-Nitro-o-toluidine	99-55-8	Benzenamine, 2-methyl-5-nitro-	8270	10
Parathion	56-38-2	Phosphorothioic acid, O,O-diethyl-O-(4-nitrophenyl) ester	8270	10
Polychlorinated biphenyls; PCBs	See Note 7	1,1'-Biphenyl, chloro derivatives	8080	50
			8250	100
Polychlorinated dibenzo-p-dioxins; PCDDs	See Note 8	Dibenzo[b,e][1,4]dioxin, chloro derivatives	8280	0.01
Polychlorinated dibenzofurans; PCDFs	See Note 9	Dibenzofuran, chloro derivatives	8280	0.01
Pentachlorobenzene	608-93-5	Benzene, pentachloro-	8270	10
Pentachloroethane	76-01-7	Ethane, pentachloro-	8240	5
			8270	10
Pentachloronitrobenzene	82-68-8	Benzene, pentachloronitro-	8270	10
Pentachlorophenol	87-86-5	Phenol, pentachloro-	8040	5
			8270	50
Phenacetin	62-44-2	Acetamide, N-(4-ethoxyphenyl)	8270	10
Phenanthrene	85-01-8	Phenanthrene	8100	200
			8270	10
Phenol	108-95-2	Phenol	8040	1
			8270	10
p-Phenylenediamine	106-50-3	1,4-Benzenediamine	8270	10
Phorate	298-02-2	Phosphorodithioic acid, O,O-diethyl S-[(ethylthio)methyl] ester	8140	2
			8270	10

Common name [2]	CAS RN [3]	Chemical abstracts service index name [4]	Suggested methods [5]	PQL (µg/L) [6]
2-Picoline	109-06-8	Pyridine, 2-methyl-	8240	5
			8270	10
Pronamide	23950-58-5	Benzamide, 3,5-dichloro-N-(1,1-dimethyl-2-propynyl)-	8270	10
Propionitrile; Ethyl cyanide	107-12-0	Propanenitrile	8015	60
			8240	5
Pyrene	129-00-0	Pyrene	8100	200
			8270	10
Pyridine	110-86-1	Pyridine	8240	5
Safrole	94-59-7	1,3-Benzodioxole, 5-(2-propenyl)-	8270	10
Selenium	(Total)	Selenium	6010	750
			7740	20
			7741	20
Silver	(Total)	Silver	6010	70
			7760	100
Silvex; 2,4,5-TP	93-72-1	Propanoic acid, 2-(2,4,5-trichlorophenoxy)-	8150	2
Styrene	100-42-5	Benzene, ethenyl-	8020	1
			8240	5
Sulfide	18496-25-8	Sulfide	9030	10,000
2,4,5-T; 2,4,5-Trichlorophenoxyacetic acid	93-76-5	Acetic acid, (2,4,5-trichlorophenoxy)-	8150	2
2,3,7,8-TCDD; 2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6	Dibenzo[b,e][1,4]dioxin, 2,3,7,8-tetrachloro-	8280	0.005
1,2,4,5-Tetrachlorobenzene	95-94-3	Benzene, 1,2,4,5-tetrachloro-	8270	10
1,1,1,2-Tetrachloroethane	630-20-6	Ethane, 1,1,1,2-tetrachloro-	8010	5
			8240	5
1,1,2,2-Tetrachloroethane	79-34-5	Ethane, 1,1,2,2-tetrachloro-	8010	0.5
			8240	5
Tetrachloroethylene; Perchloroethylene; Tetrachloroethene	127-18-4	Ethene, tetrachloro-	8010	0.5
			8240	5
2,3,4,6-Tetrachlorophenol	58-90-2	Phenol, 2,3,4,6-tetrachloro-	8270	10
Tetraethyl dithiopyrophosphate; Sulfotepp	3689-24-5	Thiodiphosphoric acid ([(HO)$_2$P(S)]$_2$O), tetraethyl ester	8270	10
Thallium	(Total)	Thallium	6010	400
			7840	1,000
			7841	10
Tin	(Total)	Tin	7870	8,000
Toluene	108-88-3	Benzene, methyl-	8020	2
			8240	5
o-Toluidine	95-53-4	Benzenamine, 2-methyl-	8270	10
Toxaphene	8001-35-2	Toxaphene	8080	2
			8250	10
1,2,4-Trichlorobenzene	120-82-1	Benzene, 1,2,4-trichloro-	8270	10
1,1,1-Trichloroethane; Methylchloroform	71-55-6	Ethane, 1,1,1-trichloro-	8240	5
1,1,2-Trichloroethane	79-00-5	Ethane, 1,1,2-trichloro-	8010	0.2
			8240	5
Trichloroethylene; Trichloroethene	79-01-6	Ethene, trichloro-	8010	1
			8240	5
Trichlorofluoromethane	75-69-4	Methane, trichlorofluoro-	8010	10
			8240	5
2,4,5-Trichlorophenol	95-95-4	Phenol, 2,4,5-trichloro-	8270	10
2,4,6-Trichlorophenol	88-06-2	Phenol, 2,4,6-trichloro-	8040	5
			8270	10
1,2,3-Trichloropropane	96-18-4	Propane, 1,2,3-trichloro-	8010	10
			8240	5
O,O,O-Triethyl phosphorothioate	126-68-1	Phosphorothioic acid, O,O,O-triethyl ester	8270	10
sym-Trinitrobenzene	99-35-4	Benzene, 1,3,5-trinitro-	8270	10
Vanadium	(Total)	Vanadium	6010	80
			7910	2,000
			7911	40

Common name [2]	CAS RN [3]	Chemical abstracts service index name [4]	Suggested methods [5]	PQL (µg/L) [6]
Vinyl acetate	108-05-4	Acetic acid, ethenyl ester	8240	5
Vinyl chloride	75-01-4	Ethene, chloro-	8010	2
			8240	10
Xylene (total)	1330-20-7	Benzene, dimethyl-	8020	5
			8240	5
Zinc	(Total)	Zinc	6010	20
			7950	50

[1] The regulatory requirements pertain only to the list of substances; the right hand columns (Methods and PQL) are given for informational purposes only. See also footnotes 5 and 6.

[2] Common names are those widely used in government regulations, scientific publications, and commerce; synonyms exist for many chemicals.

[3] Chemical Abstracts Service registry number. Where "Total" is entered, all species in the ground water that contain this element are included.

[4] CAS index names are those used in the 9th Cumulative Index.

[5] Suggested Methods refer to analytical procedure numbers used in EPA Report SW-846 "Test Methods for Evaluating Solid Waste", third edition, November 1986. Analytical details can be found in SW-846 and in documentation on file at the agency. CAUTION: The methods listed are representative SW-846 procedures and may not always be the most suitable method(s) for monitoring an analyte under the regulations.

[6] Practical Quantitation Limits (PQLs) are the lowest concentrations of analytes in ground waters that can be reliably determined within specified limits of precision and accuracy by the indicated methods under routine laboratory operating conditions. The PQLs listed are generally stated to one significant figure. CAUTION: The PQL values in many cases are based only on a general estimate for the method and not on a determination for individual compounds; PQLs are not a part of the regulation.

[7] Polychlorinated biphenyls (CAS RN 1336-36-3); this category contains congener chemicals, including constituents of Aroclor-1016 (CAS RN 12674-11-2), Aroclor-1221 (CAS RN 11104-28-2), Aroclor-1232 (CAS RN 11141-16-5), Aroclor-1242 (CAS RN 53469-21-9), Aroclor-1248 (CAS RN 12672-29-6), Aroclor-1254 (CAS RN 11097-69-1), and Aroclor-1260 (CAS RN 11096-82-5). The PQL shown is an average value for PCB congeners.

[8] This category contains congener chemicals, including tetrachlorodibenzo-p-dioxins (see also 2,3,7,8-TCDD), pentachlorodibenzo-p-dioxins, and hexachlorodibenzo-p-dioxins. The PQL shown is an average value for PCDD congeners.

[9] This category contains congener chemicals, including tetrachlorodibenzofurans, pentachlorodibenzofurans, and hexachlorodibenzofurans. The PQL shown is an average value for PCDF congeners.

APPENDIX B

EPA TOXICITY CHARACTERISTIC CONCENTRATIONS

APPENDIX B

EPA TOXICITY CHARACTERISTIC CONCENTRATIONS

(Ref. 40 CFR 261.24)

EPA HW No.	Contaminant	Regulatory Level (mg/L)
D004	Arsenic	5.0
D005	Barium	100.0
D018	Benzene	0.5
D006	Cadmium	1.0
D019	Carbon tetrachloride	0.5
D020	Chlordane	0.03
D021	Chlorobenzene	100.0
D022	Chloroform	6.0
D007	Chromium	5.0
D023	o-Cresol	200.0
D024	m-Cresol	200.0
D025	p-Cresol	200.0
D026	Cresol	200.0
D016	2,4-D	10.0
D027	1,4-Dichlorobenzene	7.5
D028	1,2-Dichloroethane	0.5
D029	1,1-Dichloroethylene	0.7
D030	2,4-Dinitrotoluene	0.13
D012	Endrin	0.02
D031	Heptachlor (and hydroxide)	0.008
D032	Hexachlorobenzene	0.13
D033	Hexachlorobutadiene	0.5
D034	Hexachloroethane	3.0
D006	Lead	5.0
D013	Lindane	0.4
D009	Mercury	0.2
D014	Methoxychlor	10.0
D035	Methyl ethyl ketone	200.0
D036	Nitrobenzene	2.0
D037	Pentachlorophenol	100.0
D038	Pyridine	5.0
D010	Selenium	1.0
D011	Silver	5.0
D039	Tetrachloroethylene	0.7
D015	Toxaphene	0.5
D040	Trichloroethylene	0.5
D041	2,4,5-Trichlorophenol	400.0
D042	2,4,6-Trichlorophenol	2.0
D017	2,4,5-TP (silvex)	1.0
D043	Vinyl chloride	0.2

APPENDIX C

BACKGROUND SOIL SAMPLE DATA

APPENDIX C

BACKGROUND SOIL SAMPLE DATA[a] (mg/kg)

	K1-P 1.645		Ka 1.645													
SAMPLE_NO	AL_CONC		SB_CONC		AS_CONC		BA_CONC		BE_CONC		CD_CONC		CR_CONC		CO_CONC		CU_CONC		PB_CONC	
MTL0801AM	14700		1.70		13.1		43		0.8		0.4		19.7		5.03		56.1		264.00	
MTL0802AM	14100		2.00		19.9		29		0.7		0.4		18.8		4.42		39.1		226.00	
MTL0803AM	15000		1.70		21.2		35		0.7		0.4		19.9		5.16		35.9		278.00	
MTL0804AM	13900		1.70		15.3		41		0.8		0.4		18.1		5.14		35.7		262.00	
MTL0805AM	14700		1.80		17.4		43		0.8		0.4		19.4		4.99		34.7		215.00	
N	5		5		5		5		5		5		5		5		5		5	
Mean	14480		2		17		38		1		0		19		5		40		249	
Stand. Dev.	460.435		0.130		3.301		5.918		0.035		0.011		0.733		0.304		8.986		27.019	

SAMPLE_NO	MN_CONC		HG_CONC		NI_CONC		SE_CONC		AG_CONC		TL_CONC		V_CONC		ZN_CONC		CN_CONC			
MTL0801AM	198		0.05	B	54.0		0.62	B	7.2		1.00	U	77.4		212		0.26	U		
MTL0802AM	152		0.05	B	50.2		0.22	B	6.0		1.00	U	67.1		191		0.28	U		
MTL0803AM	182		0.05	B	54.4		0.19	U	5.8		0.96	U	61.2		202		0.26	U		
MTL0804AM	197			B	54.9		0.39	B	6.0		0.80	U	68.4		208		0.31	U		
MTL0805AM	239			B	56.4		0.35	B	7.1		1.00	U	71.5		213		0.29	U		
				B	57.5		0.21	B	5.4		0.99	U	76.3		207		0.26	B		
				B	56.4		0.64	B	5.5		0.95	U	74.4		214		0.27			
				B	52.3		0.20	U	5.3		1.00	U	71.9		208		0.29	U		
				B	55.6		0.18	U	5.2		0.91	U	69.3		205		0.27	U		
				B	51.9		0.20	U	4.5		1.00	U	69.8		196		0.34	U		
N	5		3		10		10		10		10		10		10		10			
Mean	193.60		0.05		54.36		0.32		5.80		0.96		70.73		205.60		0.28			
Stand. Dev.	31.453		1.7e+308		2.303		0.178		0.835		0.064		4.753		7.442		0.026			

a. Background samples were surface-soil composites collected on the AMTL site. The composites were collected above the bunker, 25 ft south of the fence line surrounding the residence of the base commander. The soil is a dark loamy sand with a considerable amount of organic material. Samples were collected at 10-ft intervals along a 50-ft transect.